ARTMENT OF TECHNOLOGY
BUFFALO PUBLIC LIBRARY

AERONAUTICAL ENGINEERING REVIEW

SEPTEMBER 1953

ATTITUDES
or ALTITUDES . . .

At any altitude, the sleek Grumman F9F-6 Cougar operates at peak efficiency whether "standing on its tail" or flying on its back.

The turbine control needed to properly meter the fuel to the Cougar's powerful Pratt and Whitney J-48 Jet Engine at any attitude or altitude was designed, engineered, and manufactured by Holley.

LEADER IN THE DESIGN, DEVELOPMENT, AND MANUFACTURE OF AVIATION FUEL METERING DEVICES.

HOLLEY
Carburetor Co.
DETROIT 4, MICHIGAN

AERONAUTICAL ENGINEERING REVIEW

Cover—McDonnell Aircraft Corporation's flight test bed for research on supersonic-type propellers takes off with a feathered prop. This ship, an XF-88B, is powered with an XT-38 Allison turboprop, plus its regular two J-34 Westinghouse turbojet engines. This XF-88B propeller-research plane was developed under a project of WADC's Propeller Laboratory working with McDonnell, NACA, and the Navy.

Editor
Welman A. Shrader

Managing Editor
Berneice H. Jarck

Assistant Editor
Rita J. Turino

Reviews Editor
F. J. Harsaghy, Jr.

News Editor
Beverly A. Dodge

Book Reviews Editor
John J. Glennon

Technical Advisers
Hugh L. Dryden
Robert R. Dexter
S. Paul Johnston

Advertising Manager
Joseph P. Ryan

Business Manager
Hugh C. Judge

Adv. Production Mgr.
R. N. Lipner

Western Office
7660 Beverly Blvd., Los Angeles 36, Calif.

SUBSCRIPTION RATES

Aeronautical Engineering Review: United States and possessions, 1 year, $3.00; single copies, $0.50. Foreign countries including Canada (American Currency Rates), 1 year, $3.50; single copies, $0.50.

Entered as second-class matter at the Post Office, Easton, Pa., April 29, 1942. Acceptance for mailing at a Special Rate of Postage as provided for in the Act of August 24, 1912.

Publication Office: 20th & Northampton Streets, Easton, Pa.

Editorial Office: 2 East 64th Street, New York 21, N.Y. Notices of change of address should be sent to the Institute at least 30 days prior to actual change of address.

Statements and opinions expressed in the Aeronautical Engineering Review are to be understood as individual expressions and not those of the Institute.

Copyright, 1953, by the Institute of the Aeronautical Sciences, Inc.

Vol. 12 **SEPTEMBER, 1953** **No. 9**

Contents

IAS News 17

Annual Summer Meeting Dinner Address 20

Articles

Boundary-Layer Control and Supercirculation . . . . . John S. Attinello 24

Jet Metals . . . . . Wilson G. Hubbell 31

The Trend of Complete Aircraft and Guided-Missile Structures Toward Reinforced Plastics . . . . . William E. Braham 37

Optimum Exit-Nozzle Performance for Jet Engines . . . . . Richard G. Laucher and John S. Winter 41

Structural Comparison of Perforated Skin Surfaces with Other Means of Effecting Boundary-Layer Control by Suction . . . . . Charles B. Cliett 46

Reviews

Aeronautical Reviews 87

Books 131

New Products and Product Literature 143–146

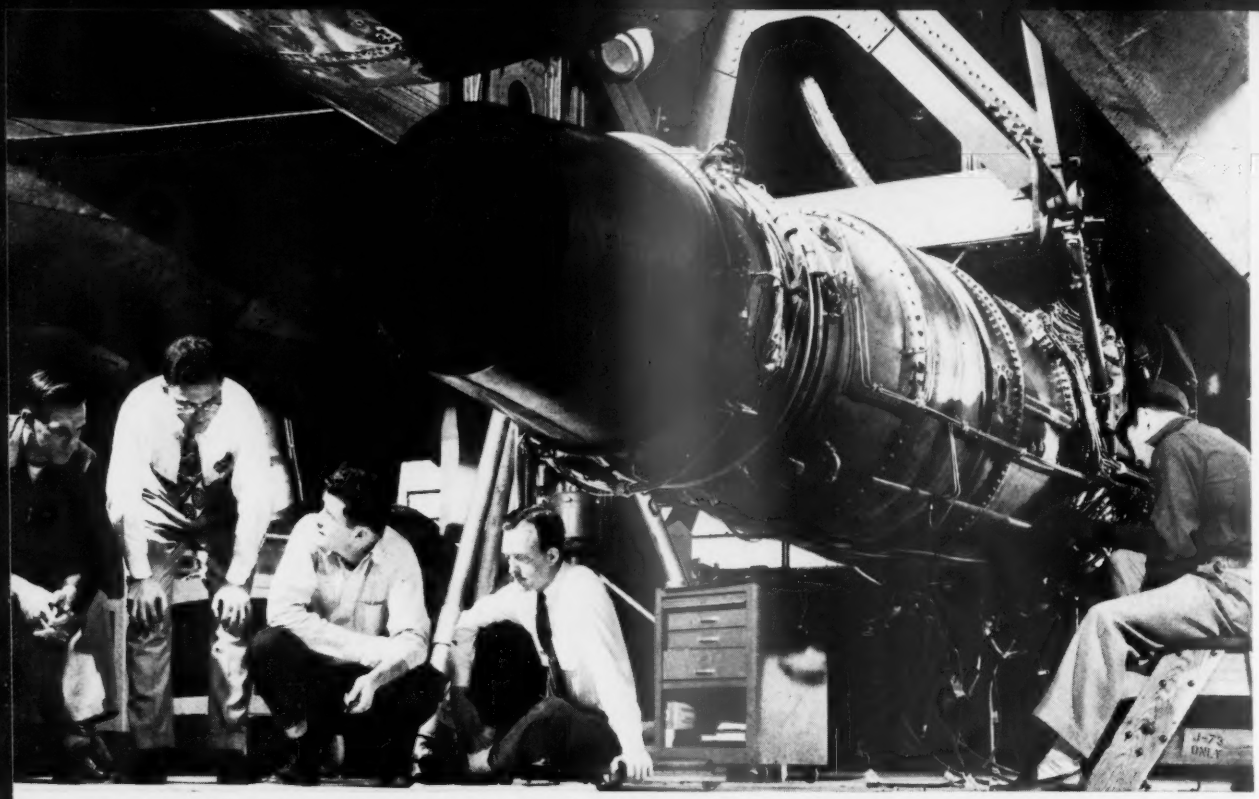
Special IAS Publications 30

Sherman M. Fairchild Publication Fund Papers . . 45

Personnel Opportunities 133

Index to Advertisers 140, 141

Published Monthly by the Institute of the Aeronautical Sciences, Inc.



G-E JET ENGINEERS study plans of G.E.'s new engine at Flight Test Center in Schenectady, N. Y. The big powerplant is lowered from B-29 during flight. G.E. looks forward—soon—to completely *integrated* armament, engine, autopilot, and electrical system testing.

"Integrated Testing" Will Improve U. S.

"X" EQUIPMENT gets frequent work-outs in hot planes like this F-86 Sabre, on bailment from Air Force. G-E armament, flight control experts are busy helping the Air Force develop co-ordinated Sunday punches for new U.S. jet planes.

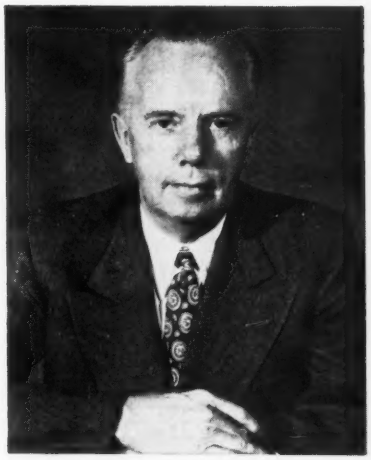
PERISCOPE? No—part of a G-E radar-autopilot-armament system. The boom (installed in B-26) measures pitch and yaw signals for determination of system performance. Such devices help G-E engineers get pin-point accuracy in flight-testing new aviation gear

IAS News

A Record of People and Events of Interest to Institute Members

Summer Meeting Sets Attendance Record for Coast

Dedication of Wright Brothers Replica, Presentation of Awards, and Speeches by Generals LeMay and Doolittle Highlight Dinner



John K. Northrop honored.

MORE THAN 850 PEOPLE PACKED the ballroom of the Statler Hotel in Los Angeles on July 15 to help dedicate this country's first full-scale replica of the Wright Brothers' original airplane. Built by 24 cooperating companies, the model was unveiled in ceremonies marked by General Doolittle's appropriate dedication speech.

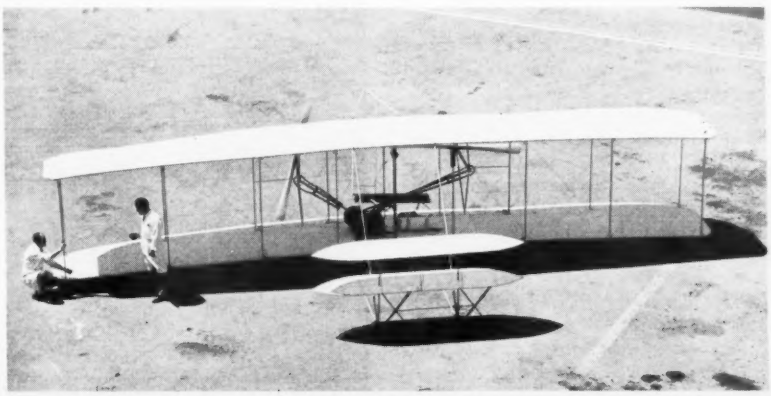
Dignitaries from all parts of the country, including eleven past-presidents of the Institute and leading industry and military figures, were present for the occasion. The evening's program, in addition to the dedication, included the presentation of the Bane and Chanute awards, a special IAS Council Award to John K. Northrop for his many years of outstanding contributions to the Institute and the aeronautical profession, and the principal address by Gen. Curtis E. LeMay. IAS President Charles J. McCarthy served as Toastmaster and made the award presentations.

A more detailed account of the Wright replica dedication dinner, and the whole of General Doolittle's speech will be carried in the next issue of the REVIEW. General LeMay's address may be found on page 20 of this issue.

▶ **Technical Meetings**—Fifteen papers on Aerodynamics, Propulsion, Structures, and Helicopter Design were presented during the 2 days of open technical meetings. A security-classified session on Guided Missiles was featured on the evening of July 16.

Most of the papers presented during the open sessions will be published in the REVIEW or JOURNAL. A summary of the various sessions will be presented by the individual chairmen in the October REVIEW.

▶ **Field Trips**—Much credit for the success of this summer's meeting goes to Marquardt Aircraft Company and to the Navy for their cooperation in providing a day of educational entertainment on July 16. Three separate groups were treated to a tour of Marquardt's interesting and well-equipped missiles laboratories. A fourth group, consisting of approximately 200 "drawn-from-the-hat" members, spent the day at sea aboard the aircraft carrier, U.S.S. "Yorktown," as guests of Rear Adm. H. D. Felt, Commander, Carrier Division Fifteen, and Commanding Officer, Capt. Wm. M. Nation, USN.



Four Air-Line Corporate Members Cited

Four IAS Corporate Members were among the 42 U.S. air lines recently named as winners of the National Safety Council's Aviation Safety Award for their contribution to safe air transportation in 1952. The four Corporate Member companies are: American Airlines, Inc.; Eastern Air Lines, Inc.; Trans World Airlines, Inc.; and United Air Lines, Inc.

Each of the winning companies qualified for this annual award in one of two ways. Either it must have completed the 1952 calendar year without a passenger or crew fatality, or it must have flown 2,000,000,000 or more consecutive passenger-miles without a passenger or crew fatality before its safety record was terminated by a fatal accident.

The records for four Corporate Member winners up to and including December 31, 1952, are:

American Airlines, Inc. American qualified under both provisions for this award. The first span of safe operation ran from November 29, 1949, to January 22, 1952, and included a total of 4,821,404,000 passenger - miles. American's second period of safe operation ran from January 22 through December 31, 1952, with more than 2,000,000,000 passenger-miles having been flown.

Eastern Air Lines, Inc. From November 1, 1949, through December 31, 1952, Eastern flew a total of 5,143,875,000 passenger-miles without a fatality.

Trans World Airlines, Inc. T.W.A. accomplished a total of 4,975,033,000 passenger-miles without a fatality from August 31, 1950, to December 31, 1952.

United Air Lines, Inc. Between August 24, 1951, and December 31, 1952, United flew 3,182,144,000 fatality-free passenger-miles.

Air Baggage Label Collection

The Institute of the Aeronautical Sciences wishes to announce an addition to the IAS Archives of seven splendidly bound and embossed volumes of air baggage labels. These volumes are the gift of Herbert A. Schoenfeld, of Tacoma, Wash., whose personal collection it was.

These seven volumes, entitled "International Air Baggage Label Album," should be of inestimable value to researchers in the field of aeronautical history. They contain 4,176 air baggage labels, which total does not include air labels or propaganda labels or etiquettes. The first two volumes consist of United States air baggage labels and United States air cargo labels. The other five volumes contain foreign ones.

Guggenheim Fellowships at Princeton

The names of the ten men who have been selected to receive Daniel and Florence Guggenheim Jet Propulsion Fellowships for advanced study and research at the Guggenheim Jet Propulsion Center, Princeton University, were announced on July 2 by Harry F. Guggenheim, IAS Member, Honorary Member, and Benefactor, President of The Daniel and Florence Guggenheim Foundation, and Dr. Harold W. Dodds, President of Princeton University. Of the ten grants, seven are new ones, and the remaining three have been renewed for an additional year of study at Princeton.

Those who have been awarded new grants are: Frank Baltakis, IAS Student Member; Arthur A. Kovitz; Andrew F. Burke; K. Evan Gray; Ernest Edward Ebrite; Sinclaire M. Scala; and Victor Kebely. The three whose grants were renewed are: Arnold Brooks; Henry E. Hoercher, IAS Student Member; and Marcel Vinokur, TMIAS.

The announcement of the nine persons who received Guggenheim Fellowships for advanced study and research at the Guggenheim Jet Propulsion Center at the California Institute of Technology was carried in last month's AERONAUTICAL ENGINEERING REVIEW. The Guggenheim Jet Propulsion Center at Princeton and the one at CalTech were both established in 1948 by The Daniel and Florence Guggenheim Foundation.

Aircraft Quality Control Conference

An Aircraft Quality Control Conference has been scheduled for November 16 and 17 at the Biltmore Hotel in Dayton, Ohio, according to a recent announcement by the Aircraft Technical Committee of the American Society for Quality Control. The program for this 2-day conference will be devoted to quality control problems now being encountered by the American aircraft industry.

All persons desiring further information concerning the program and registration will please contact: Norman F. Trost, Conference Chairman, Aeroproducts Operations, Allison Division, General Motors Corporation, Vandalia, Ohio.

Necrology

Dr. Theodor W. Zobel

Dr. Theodor W. Zobel, MIAS, Specialist, Aerodynamic Instrumentation in Components Development, Aircraft Gas Turbine Division, General Electric Company, died on April 12.

Born in Memmingen, Bayern, Germany, on February 27, 1906, Dr. Zobel was educated in his native land. After 10 years at Oberrealschule, he matriculated in 1925 at the Technikum Ilmenau. Two years later, he entered the Technische Hochschule, Berlin, and majored in mechanical engineering, physics, optics, and aeronautics. He was awarded his Dipl.-Ing. degree in 1933 and his Dr.-Ing. degree in 1936.

In 1932, Dr. Zobel became Scientific Assistant at the Technische Hochschule. For 3 years, commencing in 1935, he was a Research Engineer in Aerodynamics at Deutsche Versuchsanstalt für Luftfahrt, Berlin-Adlershof. In 1938, he became Section Chief for High Speed Air Research at Luftfahrtforschungsanstalt Braunschweig. Here, he was largely instrumental and successful in the application of techniques of interferometry to the study of airflow in wind tunnels. As a result of this, he, his associates, and their equipment were brought in 1945 to Wright-Patterson AFB, Ohio, where he served first in the Aircraft Laboratory of Air Materiel Command as Chief of the Optics Group and later in the Office of Air Research. He became associated with the component development work at General Electric in November of 1951.

Dr. Zobel, who was appointed in 1941 a member of Deutsche Akademie der Luftfahrtforschung, was the author of many research papers that had been published both in this country and in Germany. The general fields covered by these reports are aerodynamics, jet-propulsion motors, and optical flow measurements. Dr. Zobel was considered to be one of the world's experts in interferometry.

News of Members

▸ **Wellwood E. Beall,** IAS Fellow and Past-President, Senior Vice-President, Boeing Airplane Company, was awarded the Norlin Achievement Medal at the recent commencement exercises of his alma mater, the University of Colorado.

▸ **Arthur Fage** (F), Superintendent, Aerodynamics Division, The National Physical Laboratory, England, was recently made a Commander of the Most Excellent Order of the British Empire (C.B.E.). Mr. Fage's name appeared in the Birthday Honours List of 1953.

▸ **Richard K. Koegler,** Head, Engineering Branch, Flight Research Department, Cornell Aeronautical Laboratory, Inc., was recently elected President of the Technical Societies Council of the Niagara Frontier. Mr. Koegler served during 1952–1953 as Vice-President of the Council.

▸ **Dr. Paul Lieber** (M), Associate Professor of Aeronautical Engineering, Rensselaer Polytechnic Institute, is in charge of a 2-year research project for the Air Research and Development Command. Dr. Lieber and his associates at R.P.I. are making a study of electrical analogy for incompressible flow, more particularly in the use of electrical analogy for predicting steady and unsteady flows about bodies of revolution. The contract between ARDC and R.P.I. calls for the work to be completed by December 1, 1954.

▸ **James H. Smith, Jr.** (AM), a Director of Slick Airways, Inc., was sworn in on July 23 as Assistant Secretary of the Navy for Air. Prior to his association with Slick, Mr. Smith was Vice-President—Atlantic Division of Pan American World Airways, Inc.

▸ **Dr. Edward Warner,** Honorary Fellow and Benefactor of the Institute, was unanimously re-elected for a 3-year term as President of the Council of the International Civil Aviation Organization. This election took place on July 7 in Brighton, England, during the first meeting of the new Council, chosen by the Seventh Session of the ICAO Assembly the previous week. Dr. Warner has served as ICAO Council President since 1947. Between 1945 and 1947, he was President of the Interim Council of the Provisional International Civil Aviation Organization.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are therefore urged to notify the News Editor of changes as soon as they occur.

William I. Berks (TM), Research Engineer, North American Aviation, Inc. Formerly, Research Assistant, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn.

Peter Bielkowicz (M), Staff Member, Department of Aeronautical Engineering, USAF Institute of Technology, Wright-Patterson AFB, Ohio. Formerly, Assistant Professor of Engineering, Brown University.

Warren V. Boughton (AF), Vice-President, Nader Engineering and Motordyne, Inc. Formerly, Vice-President and General Manager, Phaostron Company.

Robert A. Buss (M), Assistant to System Superintendent of Flight Training and Regional Chief Pilot, Western Air Lines, Inc. Formerly, Manager, Pilot Education, Western Air Lines.

Reed M. Chambers (M), Chairman of the Board, United States Aviation Underwriters, Inc. Formerly, President, U.S. Aviation Underwriters.

Frank R. Cook (AF), Director of Research and Planning, Aeronautical Division, Minneapolis-Honeywell Regulator Company. Formerly, Director of Aeronautical Engineering, Minneapolis-Honeywell.

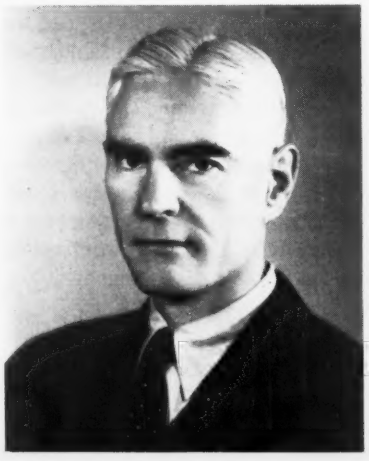
David Eisenberg (TM), Project Engineer, Mechanical Design Group, Century Electronics, Division of Century Metalcraft Corporation. Formerly, with Canoga Corporation.

Walter E. Fellers (M), Engineering Staff Member, Fletcher Aviation Corporation. Formerly, Assistant Chief of Aerodynamics, North American Aviation, Inc.

Edward H. Gunton (M), Assistant Manager in charge of Operations, Des Moines Plants, Solar Aircraft Company. Formerly, Manager, Production Engineering Division, Des Moines Plants, Solar.

(*Continued on page 56*)

J. Carlton Ward, Jr., MIAS, was elected President of The Vitro Manufacturing Company, Vitro Corporation of America, and Vitro Chemical Company. At the same time, he was made a Director of the companies, which he is joining for the first time. Mr. Ward was Chairman of the Board of Thompson Industries, Inc., from 1949 to 1953.



Colonel Robert J. Benford, USAF (MC), AFIAS, relieved Col. Wayne G. Brandstadt (MC), USA, as Editor of the *U.S. Armed Forces Medical Journal* on last July 1. This appointment makes Colonel Benford the first officer of the Air Force Medical Service to serve in this capacity. Colonel Benford, who was formerly Associate Editor of the Medical Journal, is a member of the IAS Editorial Committee on Physiological Problems and of the Advisory Boards of the *Journal of Aviation Medicine* and the *Military Surgeon*.

Igor B. Bensen, MIAS, has been elected President and Chairman of the Board of the newly formed Bensen Aircraft Corporation, located at the Raleigh-Durham Airport, Raleigh, N.C. The activities of this corporation, of which Seth R. Thompson is Vice-President and Mary A. Bensen is Secretary-Treasurer, includes primarily development, research, consulting, and subcontracting services to the helicopter industry. Mr. Bensen was formerly Chief of Research, The Kaman Aircraft Corporation. He is still retained by Kaman as Consulting Engineer.

Strategic Air Command

by

Gen. Curtis E. LeMay, USAF

Commander of Strategic Air Command

at the

Annual Summer Meeting Dinner

Los Angeles, Calif.

July 15, 1953

A great percentage of you, I realize, is directly involved in classified projects in the research and development fields for the Air Force. But as much as I would like to talk along these lines, I think you will appreciate that it is necessary for me to deal only with unclassified information.

I propose, within that limitation, to discuss briefly the origin of the Strategic Air Command; then, to review with you its operation and present capabilities; and, last, to tell you how we are getting along with the equipment that we now have in service.

It is difficult to pin down the exact origin of the doctrine of directing air power against the sustaining resources of an enemy nation. It must have been sometime in World War I. Certainly it persisted in the Twenties as a strong belief, and in the Thirties there emerged from this belief a firm concept that has profoundly influenced not only the nature of our military forces but also the outcome of a great war and the course of world history.

The story of strategic air power in World War II need not be retold here. I will note that we had to build our strategic bombing force after the war started, and it took 3 years to do it. Eighty-three per cent of the total tonnage of bombs delivered against German targets were dropped in the last year of the war. A staggering tonnage was dropped on Japan in just the last 6 months prior to its surrender.

In the case of both nations, at capitulation the resources and the will to continue were gone—an axiom of the original doctrine. The Strategic Air Command is our present-day instrument of the concept of strategic air power. It is a natural result of the evolution of that early doctrine and is shaped by 35 years of air development and development in the field of weapons.

Dinner Address

It was established in 1946 as a major air command, and the mission assigned it by the Joint Chiefs of Staff, briefly stated, is: to be prepared to conduct offensive strategic air operations on a global basis.

Before going further, I would like to place SAC in its proper perspective within the Air Force for those of you who may not be entirely familiar with the military structure.

The Air Force has three major combat commands, in addition to those performing support functions. The Air Defense Command, equipped with fighter-interceptor aircraft, has the responsibility of defending the country against enemy air attacks. The Tactical Air Command, with fighters and light bombers, supports the ground forces in the front-line areas. The Strategic Air Command is the long-range atomic striking arm of the Air Force and is organized as follows:

Headquarters is located in Omaha. The command embodies two overseas air divisions and three combat air forces—the Fifth Air Division in French Morocco, and Seventh Air Division in England.

The Second Air Force, with headquarters at Shreveport, La., controls bases in the southeastern United States and Puerto Rico. The Eighth Air Force, with headquarters at Fort Worth, Tex., controls bases generally situated in the central part of the United States. The Fifteenth Air Force, with headquarters at Riverside, Calif., commands bases in the western part of the United States.

Each Air Force has a composite array of aircraft making it more or less tactically self-sufficient.

For example, the Eighth Air Force has heavy bombers at Carswell AFB, medium bombers at Biggs and Walker AFB's and fighters at Bergstrom AFB. Each medium bomb wing has its own tankers as part of the wing.

As many of you know, the major portion of the SAC striking force is composed of bombers, both medium and heavy, but no less essential to its effective operation are the tankers, reconnaissance, cargo, and fighter aircraft.

At the outset of a major war, SAC's medium and heavy bombers, operating from the United States and prepared advance bases in other parts of the world, would immediately mount simultaneous attacks against a great many selected targets located over a wide geographical area of an enemy's homeland. These coordinated, nation-wide attacks would be directed against selected objectives including bases, industrial complexes, communications centers, sources of power, stockpiles of material, and other targets in support of area commanders. The attacks would be designed to cause serious damage to enemy offensive air capability and to destroy the vital elements of his war-making capacity.

I think it is generally conceded that our long-range atomic bomber force with its formidable power has been the indispensable deterrent to aggression these past few years—the force that has kept the peace. Certainly we in the Air Force like to think of it that way.

SAC's present potential as a force for peace or war stems from its weapons, coupled with high-performance planes, highly skilled crews, and its readiness. The requirement for these have prompted the most searching kind of evaluations—designs and redesigns of training programs and modifications of present equipment, doctrines, and procedures. I believe an examination of these and some of the other significant requirements will be of interest to you, both professionally and as Americans sharing in the nation's high hopes for peace, security, and progress. (*Continued on page 22.*)

To begin with, all SAC combat units are maintained in a combat-ready condition. In addition to readiness of aircraft and equipment, personnel are required to be ready; all of their personal affairs, including medical inoculations, are kept up to date.

Essential unit equipment, the minimum equipment immediately required for short-term operation, is maintained in a readiness condition. "Fly-away" kits, consisting of aluminum bins on castors, are packed with critical aircraft spares for quick hoisting into bomb bays and movement to forward areas. These kits always accompany the tactical aircraft and will support a wing for 30 days' operation, wherever the wing may be sent.

SAC must be prepared to deliver bombs to targets at any point on the face of the globe. Although heavy bombers can operate effectively from bases in the United States, our medium bombers with intermediate range must operate from advanced bases nearer the potential target areas. This system requires forward bases and support aircraft to deploy essential elements into position. Our mobility plan calls for phased movement, which means that equipment needed immediately is provided first, while equipment not immediately required is phased in during later periods.

In connection with the deployment of units, we find it essential to maintain an extensive maneuver schedule. Two basic purposes are involved: First, every combat unit must be familiar in detail with geography, base facilities, weather, and conditions existing at the overseas bases; and, second, only through actual operations can we determine the deficiencies at forward bases.

SAC's mobility capability has been demonstrated by a number of operational movements to combat areas. For example, in the summer of 1950, SAC was directed to move four bomb wings to the Far East for operations against North Korea. Only short notice was given. The first two units departed their United States bases and were dropping bombs on North Korea 9 days later from bases on Okinawa. The third unit made it in 7 days and the fourth unit in 6 days.

Last year, SAC was ordered to rotate fighter wings to Japan with emphasis on safety rather than speed. Although you possibly read press accounts of this move, I would like to review the principal features.

The first move, labeled Fox Peter One, sent the Thirty-First Fighter Wing out of Turner AFB, Albany, Ga., to Yokota Base (just out of Tokyo), passing through California, proceeding on to Hawaii by use of in-flight refueling, and then island-hopping the rest of the way. The move was made in 12 days, covering a route of 10,500 miles. It could have been made in much less time had the occasion warranted it.

The second operation, Fox Peter Two, moved the fighter wing based at Bergstrom, Tex., to Japan by way of only two Pacific bases and with refueling required twice. Fox Peter Two covered a distance of 7,700 miles in 19 hours flying time.

Earlier, I referred to SAC's requirement for highly skilled crews. I think you may be interested in a thumbnail sketch of a typical SAC aircraft commander. The average AC, as we call them in SAC, is a mature technician of 32. He bears little resemblance to the young pilots who fought in the last war. He has been married 4 years and has two children. His average flying time is 3,670 hours, and he has been on a SAC crew slightly over 2 years.

The SAC bomber commander and his crew can accomplish their job only through teamwork and realistic experience. About once each week they must fly a simulated bombing mission, a duplicate of the mission they will fly if the bell rings (except for the location of the target and the type of bomb they load). On these missions they have to meet rigorous minimum training requirements, and they are scored on their bombing accuracy evaluation, navigation, pilotage, and overall performance. A means of scoring bombing runs against industrial complexes has been developed and proved highly satisfactory. During the past several years, we have made many thousands of scored runs against all types of targets.

As a matter of interest, the bombing accuracy of these crews has increased some 600 per cent in the 8 years since World War II. This is due to both better equipment and continuous practice. The average margin for error is today well within the effective range of our weapons.

Although it is difficult to translate this progressive increase in bombing accuracy into a practical example, I think I am safe in saying that 80 bombers today can do the job it would have taken 100 to do just 3 years ago. When you consider the vast destructive potential of one bomber, you can readily see why we have worked so hard to achieve this degree of precision. With our limited resources, this extra dividend may be needed urgently one day to tip the balance in our favor.

The finest bomber you can build would be useless unless its crew were capable of finding and hitting its target. By the same token, the finest crew is useless unless its aircraft has the range, speed, load-carrying capacity, and altitude characteristics which will enable it to penetrate the enemy's defenses and reach the target area.

Although penetration of enemy territory is a complex problem, and I cannot deal with it in detail here, I would like to cover a few basic points.

We have learned from history that the offensive weapon comes first. Then the defense against it is developed through necessity. Each new weapon affects the balance temporarily until the defense can work out a solution to bring the situation into balance. During the last war we saw a number of examples. Perhaps the German submarine campaign is a good one. It began, as you will recall, with the "subs" sinking ships faster than we could build them and ended with the subs being driven from the sea by a complex variety of "sub-killing" weapons.

The struggle of one technology against another—the offense against the defense—is a part of a never ending battle. Our job in SAC is to constantly evaluate the

picture with respect to air defenses, to plan ahead, to anticipate, and to be ready for the contingencies.

Today, because of the improvements in the range, speed, and altitude of our aircraft, it would appear that defense is somewhat behind offense. Our own Air Defense system, I believe, is probably the most highly developed in the world today. Yet, I do not think that the most optimistic of us feel it is capable of stopping a determined, well-planned, and coordinated bombing attack at this time.

Let me say, in complete fairness, that the advent of the jet fighter and longer range antiaircraft guns since World War II has strengthened considerably the capability of air defense systems, and an operational antiaircraft rocket may further augment the systems in the future. However, there have been developments on the other side which favor offense and tend to counteract the advances made in Air Defense.

For one thing, the nature of our present weapons has vastly reduced the number of aircraft which must be thrown against any given target system. With our present radar bombing equipment it is possible to destroy precision targets in conditions of weather which would seriously restrict the operation of intercepters. I do not mean to imply that we would not lose aircraft—undoubtedly we would lose some but not enough to affect seriously the results of our mission.

As a point of interest, rather than importance, at this juncture, I might mention that B-29s have been bombing over North Korea regularly for 3 years. They have dropped more tons than we dropped in Japan in World War II. Despite the fact they are restricted to medium altitude and a small target area, we have lost only about one bomber each month and one-half as a result of flak and the MIG-15.

Naturally, this is not a safe yardstick against which we can estimate conditions in a major war nor is it given weight in our calculations, but certainly it poses interesting questions that must, for the time being at least, go unanswered.

Practical experience that does enable us to estimate our ability to penetrate air defenses is gained in frequent maneuvers with both the United States Air Defense Command and the Royal Air Force.

In these exercises our bombers approach the frontiers in exactly the same manner they would approach the enemy in war. The defense forces, which have as much training experience to gain from the exercises as we do, make an all-out effort to intercept our bombers. I will say something about the results later on.

At this time, there is another aspect of overall SAC capability which I wish to discuss, and that is the performance of our present aircraft and aircraft equipment in getting the bombs over the target with a maximum of efficiency. Because of the limited resources in aircraft and weapons that I previously mentioned, it is necessary to get the maximum return for the effort expanded. Obviously, the only effective aircraft are those that you can get over the target with completely operational equipment.

Evaluation missions for all of our bombers are conducted quarterly. From these missions we can determine how many planes will never leave the ground and the exact reason. We know the number of planes that will abort the mission en route to the target and what percentage of these will have engine trouble and what kind of trouble it will be. We know how many will have radar bombing equipment failure and where that failure will occur. We also know how many will have partial radar failure, and we have calculated the approximate error that it will cause in their bombing accuracy.

Since these evaluation missions are conducted against defenses under combat conditions, we can determine how many aircraft we will lose to enemy action.

When the total number of aircraft which will never get off the ground, the number that will be air aborts, and the number shot down are totaled and when the bombing error of those with partial radar failure is calculated with the bomb results of those effective over the target, we know our capability.

Each phase of every exercise is cataloged and studied in minute detail by expert civilian and military air technical analysts who are convinced beyond doubt, as I am, that we can accomplish our mission. We must not, however, overlook the serious effect of equipment failure on our overall effort.

I will use a hypothetical mission to illustrate this point. Let us say, for simplicity, that 100 bombers are order on a long-range radar bombing mission. Of these 100 bombers, we can expect, say, ten of them will become pretarget aborts. This percentage, plus those lost to enemy action, will not hit the targets. There are many causes of aborts, of course, but by far the largest classification is failure in the electronic equipment. In fact, on this hypothetical mission I have described, we can expect that more than half of the ten pretarget aborts may be caused by radar failure.

As you can well appreciate and as is borne out in the illustration, some of our electronics equipment is just too complex for the function required of it, and it is not as reliable as it must be. I will add, when it is working, the results are remarkable. Considering the pioneering nature of much of the new equipment, the picture on the whole is not too bad. But the rapid elimination of the questionable areas of reliability in the equipment we are now using is of continuing and pressing concern to all of us.

Incidentally, the volumes of data we have compiled under combat conditions on equipment failure are available to those of you engaged in research, development, or manufacture of the equipment we use. This information should be in the hands of those who need it in their work, because even a small improvement will directly increase the weight of attack which we can lay down on an aggressor.

The malfunction of a single small vacuum tube in a bombing system can cause a 92-ton atomic bomber, with the destructive potential of hundreds of World War

(*Concluded on page 54*)

Boundary-Layer Control and Supercirculation*

JOHN S. ATTINELLO†
Bureau of Aeronautics

EVER SINCE 1904, when Prandtl spoke "Upon Fluid Motion with Very Small Friction," the subject of boundary-layer control has attracted and challenged the aerodynamicist. However, in nearly 50 years of aviation, *tests* of boundary-layer control have *not gone* beyond the *experimental* stages. The reasons boundary-layer control has *not* been adopted for production aircraft in the past may be summed up as follows:

(*1*) There is a *lack* of suitable *air pumping* machinery —i.e., light weight, compact devices capable of moving large quantities of air.

(*2*) There are *difficulties* in obtaining *duct* construction compatible with aircraft structural and weight requirements.

(*3*) Most of the *early investigations* were of an *empirical* nature, which made it difficult to determine the mechanism of boundary-layer control. Hence, this prevented improvement of the overall efficiency of the system.

The jet-powered airplane has now changed the boundary-layer control picture. Thinner airfoils, swept plan forms, and increasing wing loadings, which are necessary to meet high-speed requirements, are incompatible with the low-speed requirements for landing and take-off. Hence, there is now greater need for a method of *increasing wing-lifting effectiveness*. For the jet-driven aircraft, the engine itself provides the logical source of energy for boundary-layer control applications. Utilizing the jet engine solves, in part, the requirements for suitable air-pumping machinery.

Before continuing, it is desirable to *define boundary-layer control*, since this term has been used to include all methods of influencing flow by sources or sinks. In general, the boundary layer is the film of fluid immediately adjacent to a body moving through the fluid. The boundary layer may be laminar, turbulent, or not quite either, which is called transitional, and further the boundary layer may be attached or separated from the surface of the body considered. The thickness and other characteristics of the boundary layer are functions of the local pressure gradients, Reynolds Number, and surface roughness. If the boundary *layer* is *maintained laminar* and *unseparated* as it moves over the body, *friction drag* and *form drag* are thereby reduced. Attempts to prevent the boundary layer from becoming turbulent or separating from the body by means of suction or blowing slots, *suitably* placed on the body, are *correctly termed boundary-layer control*. For this application, boundary-layer control improves the "cleanliness" and, hence, the L/D of the airplane. Of course power for such "*laminarizing*" *of the flow* must be maintained throughout the cruise condition of the airplane. There is presently a heated discussion over the practicability of this type of boundary-layer control, but no further consideration will be given to boundary-layer control for *drag reduction* in this presentation.

I wish to touch briefly on some of the aspects of improving the *lifting effectiveness* of wings to reduce landing and take-off speeds of aircraft. The reasons for concentrating on improving the lifting effectiveness of wings are apparent from Fig. 1, which illustrates the tremendous rise in high speed in recent years. The resulting increases of the landing and take-off speeds *imply larger* and more expensive *airport runways* for land-based aircraft and *greater demands* on *catapulting* and arresting gear for *carrier-based* aircraft. Further, accident rates, including ILS landings, increase rapidly with increasing landing speeds. Therefore, for both economy and safety of operation of nearly all high-speed aircraft, a reduction in landing and take-off speed is highly desirable.

The speed for landing and take-off is a function of wing loading and reciprocal of the maximum lift coefficient, as

$$V_{min.} = k\sqrt{W/S\ (1/C_{Lmax.}')}$$

Presented at the Washington, D.C., Section, IAS, March 3, 1953.

* The opinions and assertions expressed herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Establishment at large.

† Head, Supersonic Aerodynamics Section.

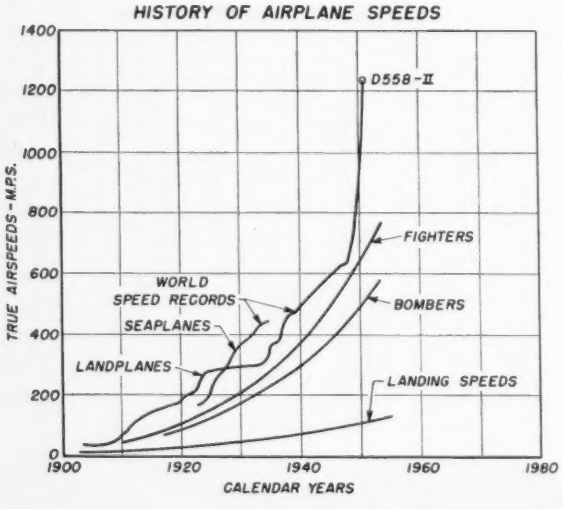


FIG. 1.

EFFECT OF BOUNDARY LAYER CONTROL AND SUPER CIRCULATION ON THE LIFTING CHARACTERISTICS OF A WING.

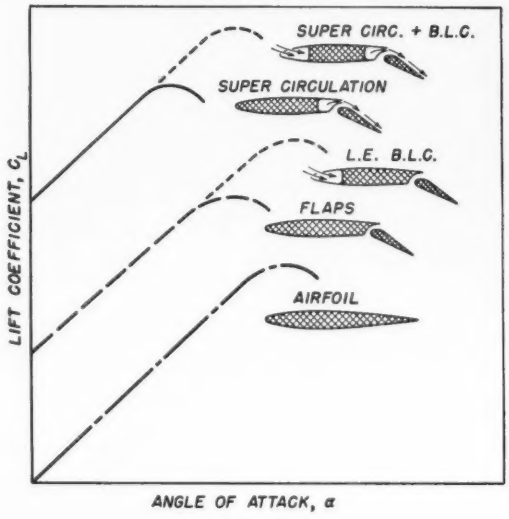


FIG. 2.

Wing loadings of military aircraft have more than doubled in the last 10 years, and the thinner airfoils and swept plan forms have also reduced $C_{L_{max.}}$ considerably. This trend is paralleled in commercial aviation also. The penalties of decreasing wing loading are severe, resulting in a ballooning of the entire airplane in *size and weight* to meet a given combat problem. Means for *increasing* $C_{L_{max.}}$ *by proper application* of boundary-layer control and supercirculation, have been the aim of researchers attempting to improve the low-speed performance of modern aircraft.

As was explained earlier, boundary-layer control *could reduce drag* by preventing separation of flow over the body surface (see Fig. 2). If this separation is prevented on an airfoil, as often occurs at the leading edge of relatively sharp-nosed, thin sections, the airfoil is permitted to continue to larger angles of attack and, hence, produce greater lift. The lowest curve ($C_L - \alpha$) is a typical unflapped airfoil. If a flap is added to the airfoil, the resulting increase in airfoil camber and, hence, increased circulation is evidenced by a shift of the lift curve to the left. Greater lift coefficients, at correspondingly smaller angles of attack, are then possible. If leading-edge separation causes stall, a form of boundary-layer control, such as suction through porous material or a slot near the leading edge, will permit the airfoil to continue to higher angles of attack and resulting increases in C_L. In this case, the action of boundary-layer control is similar to that of leading-edge slats. Now, if air were ejected over the flap, we would discover that even greater lift coefficients can be obtained and, again, at lower angles than for flapped airfoils alone. This *lift curve evidence*, together with *dynamic pressure* surveys and *smoke-tunnel* photographs, *confirms* that the effect of such a source is that of *superimposing additional circulation strength*, on the *field* about the airfoil. Hence, we have the term supercirculation or circulation control to differentiate this effect from boundary-layer control. Again, if applicable, we may extend the lift curve of the airfoil with supercirculation, by proper boundary-layer control. It can be appreciated that attempts to apply boundary-layer control at the leading edge of a wing where stalls begin at the trailing edge would be futile. Hence, *proper* application is essential.

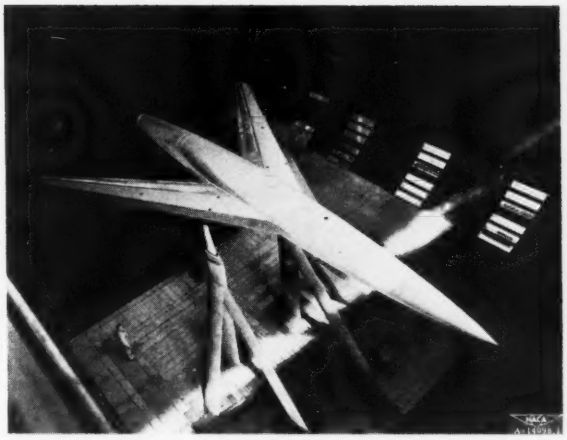


FIG. 3.

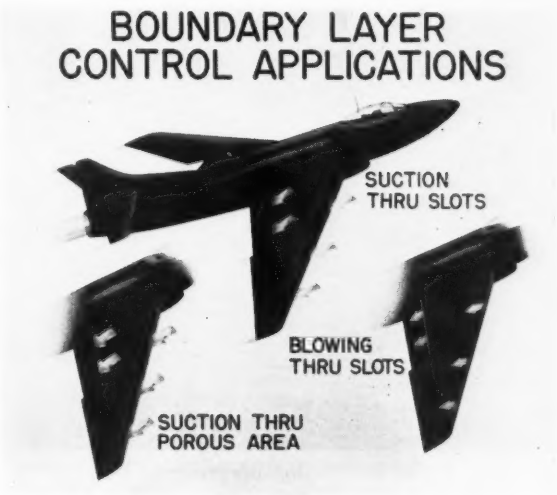


FIG. 4.

In a recent inspection of NACA Ames facilities, some of the various methods for boundary-layer control and supercirculation were exhibited. These, together with some of the porous leading-edge investigations on such sweptback wings, are shown in Fig. 3. During the inspection, an F-86 Sabrejet-fighter wing was mounted in the full-scale 40- by 80-ft. tunnel equipped with porous leading-edge boundary-layer control. Landing speeds of the order of *60 knots*, for the normally *100-knot* landing speed of this airplane, were predicted by NACA personnel.

Applications of blowing and suction at various locations are shown in Fig. 4. Suction through porous

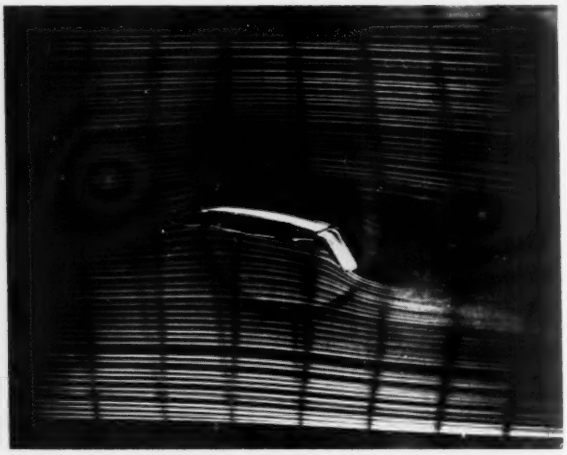


FIG. 5.

FIG. 6.

areas, suction or blowing through slots, show some of the various combinations possible.

Fig. 5 was taken with the assistance of Professor Hazen of Princeton University. The flow field about an airfoil with a droop nose and a slotted flap was photographed in the university's new smoke tunnel. Notice the extent of flow above, below, and ahead of the section, which has been influenced by the flapped airfoil. Also notice the separation over the flap at approximately 45° flap deflection.

Now in Fig. 6, we have pictured the same airfoil and angle of attack, with supercirculation—i.e., blowing over the flap in the manner of Regenscheit and Schweir. Notice the extent of influence and the effect of a stronger circulation. Observe the readherence of the flow to the upper surface and also to the flap. This effect was noted by Razak of the University of Wichita in a series of dynamic pressure surveys above and below a wing model of the Cessna-170.

In Fig. 7, without blowing, the ratio of local to free stream dynamic pressure (Q/Q_0) is shown by the circle symbol (○), while the increase over the upper surface and decrease on the lower surface is shown by the triangular symbol (▽). Razak also obtained similar surveys *for* a *suction* flap.

The type of suction shown in Fig. 8 exhibits the characteristics of supercirculation, since it utilizes a relatively enormous slot compared with that suitable for boundary-layer control. In addition, the suction quantities are of the order of 10 to 30 times that for boundary-layer control. Suction at the flap-gap improves the efficiency of the flap, *approaching* and *possibly exceeding* that of *potential flow*. This investigation of both suction and blowing type of supercirculation systems by Razak was the result of a phase of the Low-Speed Flight Research Program of the Office of Naval Research, Air Branch.

Several years after the end of World War II, it was determined that considerable *priority* was given to so-called high-lift boundary-layer control by the German aircraft companies. Among them were the Dornier company with application to the DO-24, similar to our PBY Catalina, the Messerschmitt company on their ME-109 fighter, and the Arado company on the Arado-232 troop transport and Arado-234 turbojet bomber.

The high lift system employed on the Arado-232 and DO-24 aircraft was a combination of suction and blowing: a suction flap from fuselage to approximate midspan and a blowing slot ejecting air over the remaining flap and drooped aileron (see Fig. 9). In place of heavy and bulky compressors or fans, jet pumps, using hydrogen-peroxide decomposition products for the driving nozzles, were used to move the necessary quantities of air to achieve high lift coefficients. In this manner, the pumping problem and ducting problem were solved. The two flow coefficients that determine

DYNAMIC PRESSURE RATIO NEAR AIRFOIL SURFACE WITH AND WITHOUT BLOWING "B.L.C." SYSTEM.

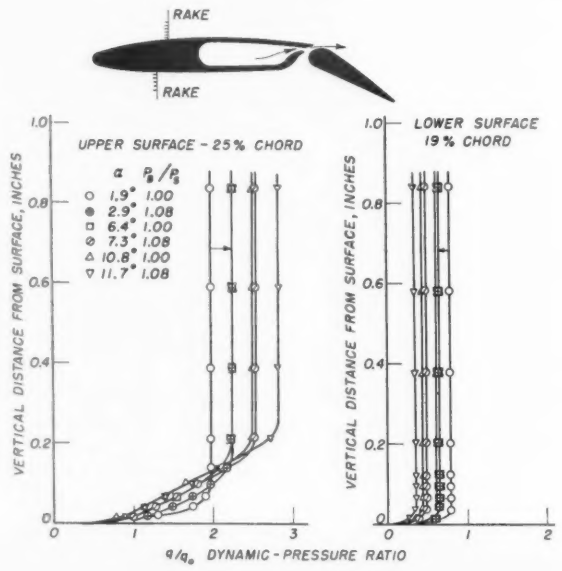


FIG. 7.

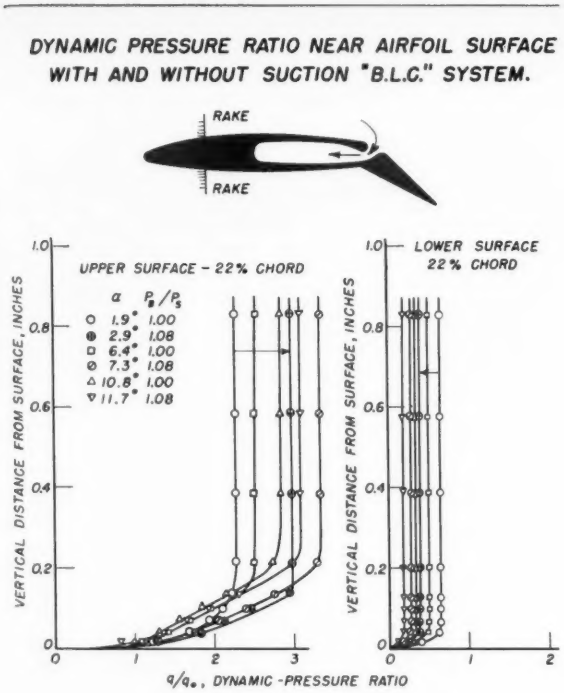


FIG. 8.

the aerodynamic characteristics of an airfoil with supercirculation are the quantity coefficients C_Q and the pressure coefficients C_P. These are defined as:

$$C_Q = Q/v_0 S$$

where Q is in volumetric terms, v_0 is the free stream velocity, and S the wing area effected by the system; and

$$C_p = \Delta P / q_0 = (P_{\text{duct}} - P_0)q_0$$

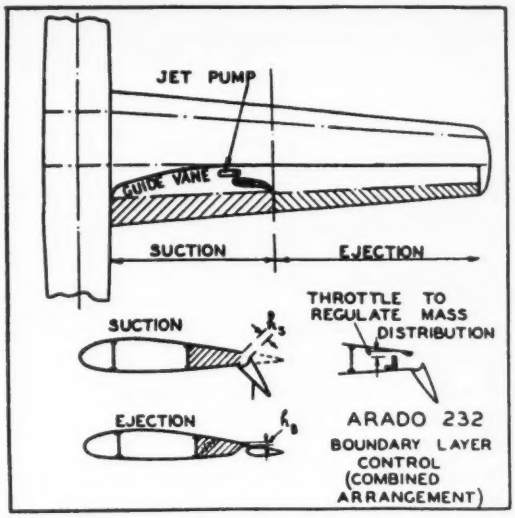


FIG. 9. Boundary-layer control system of the Arado 232.

The power for pumping the required air is:

$$HP = \Delta P \cdot Q \cdot /550$$

The aerodynamic characteristics of boundary-layer control and supercirculation systems are plotted against these parameters.

The Arado-232 was powered by reciprocating engines, not jet engines. Why, therefore, was this airplane successful in the application of supercirculation when others had failed? First, a power source compatible with aircraft requirements had been found. It was the *jet pump*, using high-pressure steam from decomposing concentrated hydrogen peroxide. The power plant was simple, relatively small, light in weight, and capable of pumping large quantities of air. The second major factor in its success was the utilization of the re-

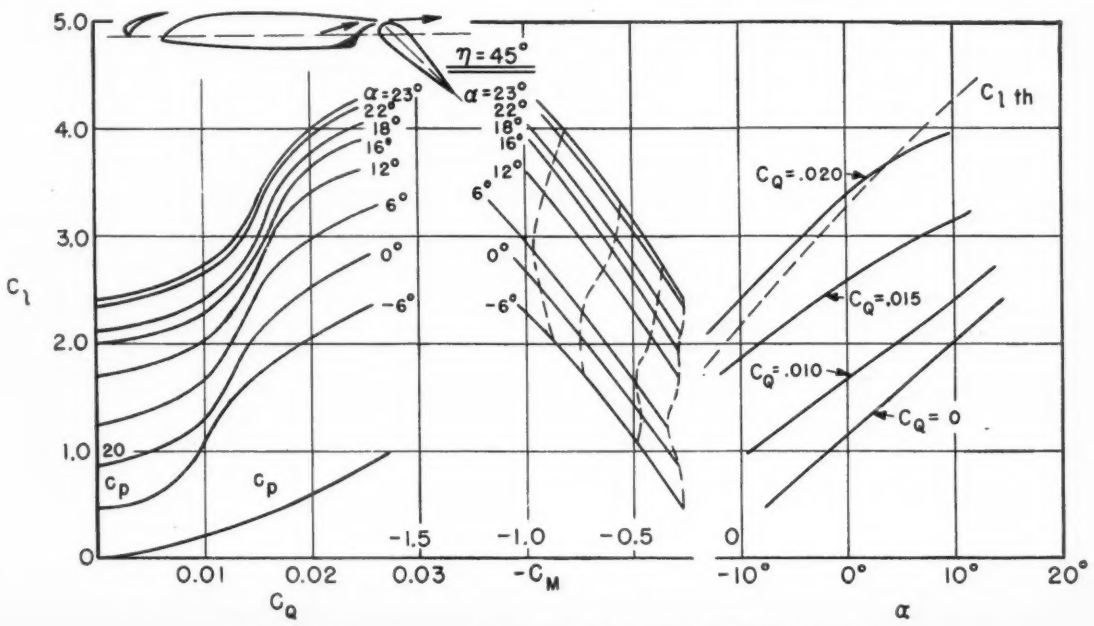


FIG. 10. Wing with slotted flap, $S = 0.005l$. (NACA 23012-64 Airfoil.)

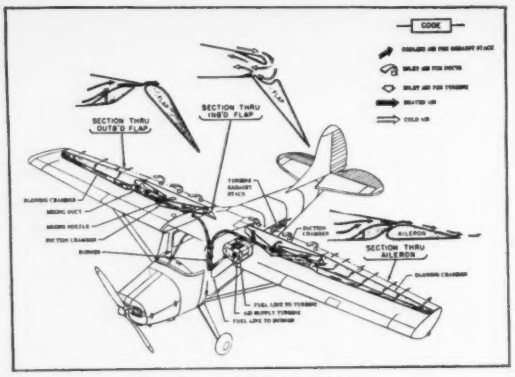


FIG. 11. Boundary-layer control for Cessna-170.

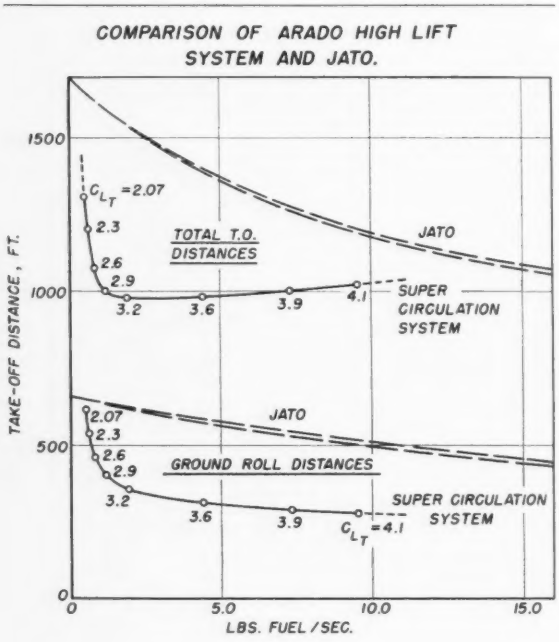


FIG. 12.

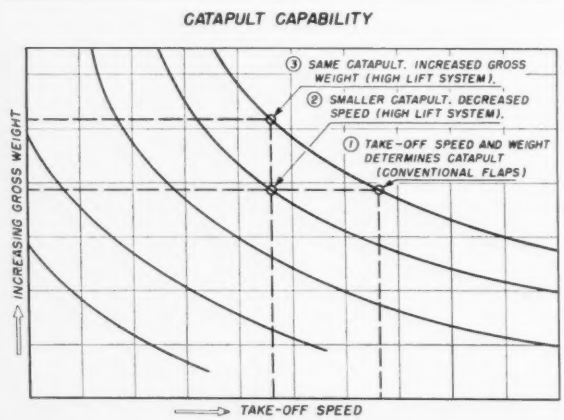

CATAPULT CAPABILITY
③ SAME CATAPULT. INCREASED GROSS WEIGHT (HIGH LIFT SYSTEM).
② SMALLER CATAPULT. DECREASED SPEED (HIGH LIFT SYSTEM).
① TAKE-OFF SPEED AND WEIGHT DETERMINES CATAPULT (CONVENTIONAL FLAPS)
INCREASING GROSS WEIGHT
TAKE-OFF SPEED

FIG. 13.

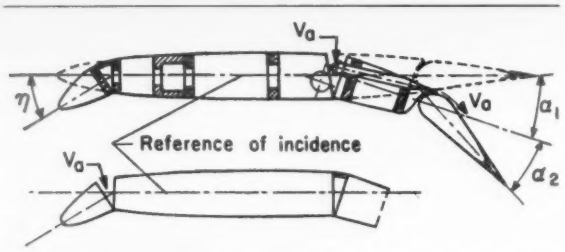


FIG. 14. Section of profile: suction from first flap or the leading edge.

quired air twice—that is, air drawn in the suction slot was ejected from the blowing slot. A corresponding reduction in duct sizes and pump power was then realized by this ingenious arrangement. This system of supercirculation is called the "Arado System."

Let us examine a typical lift curve of an airfoil with supercirculation (see Fig. 10). This is on a 12 per cent thick airfoil with blowing only and illustrates the effect of increasing the quantity of air for a given flight speed and wing area. We see that an increase in C_Q, the quantity coefficient, results in a corresponding increase in C_L at a given angle of attack. Similar characteristics are exhibited by a suction airfoil. This fact was exploited in the Arado System, since only one-half the required quantity of air was handled by the pump and ducts. The air drawn in over one-half the wing was ejected over the outer panel.

Fig. 11 shows the Arado System as used in the Cessna-170. However, in place of a hydrogen-peroxide jet pump, a unit supplying hot, high-pressure gases was used. This device was the result of Razak's work under a Navy contract. Unfortunately, the efficiency of this unit was lower than predicted; however, it provided a means for pumping for relatively long periods. This permitted research flight tests to be conducted on the Cessna without lengthy preparations and the time limitations of a rocket-propellant type of power unit. The advantage of rockets or high-energy fuel, for short durations of operations, as for landing and take-off times, would be the large amounts of power for relatively low fixed weight. The modified Cessna, designated the Cessna-309, was flown at NAS Anacostia last year at 40 m.p.h. only *a few feet from the runway* to show the complete control reliability at a speed 11 m.p.h. less than the stall speed of the commercial version at the same weight. The stall speeds were 15 m.p.h. slower for the 309 than for the 170, and the take-off ground run was some 40 per cent less than the normal take-off distance of the 170.

As was mentioned earlier, the Arado-232 was equipped with a hydrogen-peroxide system. As was also shown, an increase in the quantity of pumping—i.e., C_Q, resulted in increases in lift coefficient C_L. An interesting comparison can be made between JATO and the Arado supercirculation system if we compare the improvements in take-off for each method at various rates of fuel flow.

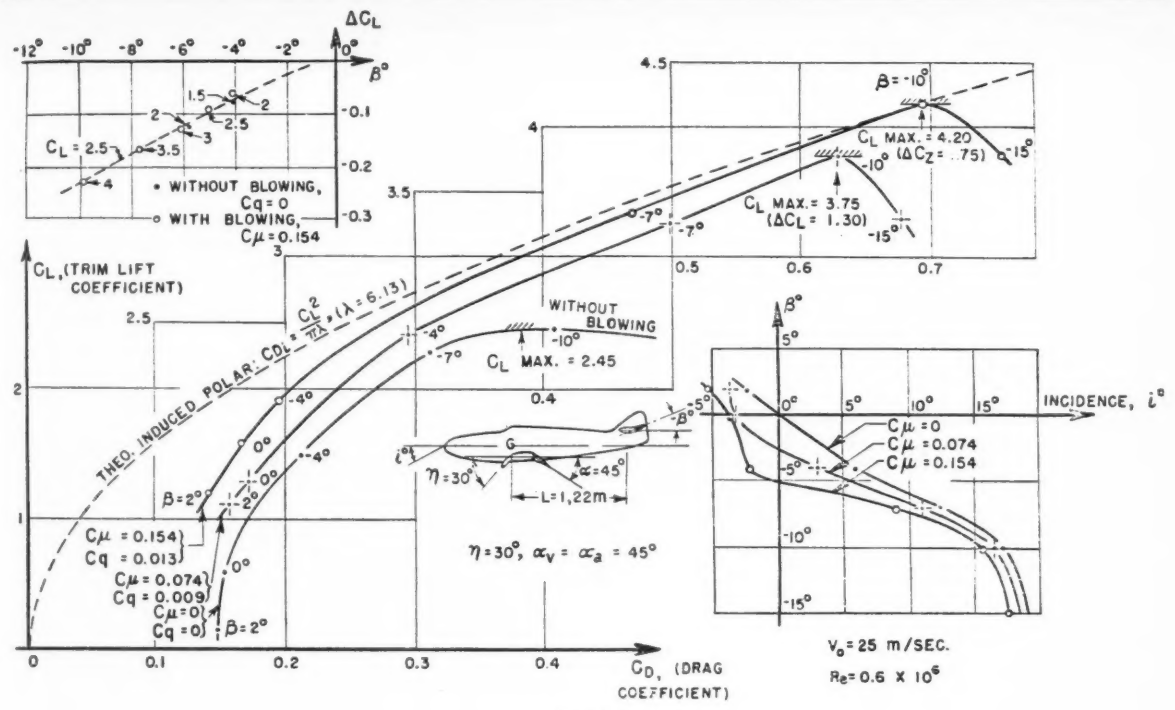


FIG. 15.

For ground roll distances, in Fig. 12 we see how at relatively low fuel consumption rates, for the jet pumps, there is a rapid reduction in take-off distance. Only a gradual reduction in distance is possible with increasing JATO power. At a rate of 5 lbs. per sec., JATO has reduced the 660-ft. ground run only 90 ft., whereas the Arado high lift system has cut the distance 360 ft. Over a 50-ft obstacle these curves show the same trend at low rates, while JATO becomes equal to the high lift system at very high consumption rates. I believe it is obvious that JATO would be useless for landing, hence, the obvious advantages to supercirculation systems are heightened by its adaptability to both landing and takeoff.

For Naval use, ground run would be more significant than distance over a 50-ft. obstacle. In Fig. 13, a set of possible performance curves of catapults (solid lines) are plotted. The larger catapults are to the right and are capable of launching aircraft at higher gross weights and speeds.

For a given airplane, the speed of take-off at some weight is represented by the circle. By the addition of a supercirculation system, we can reduce the take-off speed and now launch the same airplane from a smaller catapult, or with less wind over the carrier deck. Another alternative is to load up the airplane to a higher gross weight and still be permitted to use the first catapult. The situation for arresting gear is similar to the catapult, since arresting gear is an energy absorbing system and any decrease in landing speed will permit a higher landing weight or use of smaller equipment at the same weight.

Although the first Navy research effort has been a duplication of the Arado System, this is by no means an indication that this type of supercirculation should be used for other aircraft types (see Fig. 14). The French ONERA, equivalent to the U.S. NACA, has displayed much ingenuity in a recent full-scale installation of a thin swept wing, wherein bleed air from the jet engine is used in the driving nozzles of a series of flattened jet pumps, which, in turn, exhaust over the flap. The double flap arrangement, shown in this figure, permits suction at the first opening of the double flap from the suction side of the pump. Suction behind the drooped nose is made possible by chordwise openings between ribs, leading to the suction side of the jet pumps. Also, these suction points are to prevent separation of flow over the thin swept wing. A ΔC_L of 1.36 was obtained for this system of high lift. One of the disadvantages of the Arado System was the requirement that the ducting be entirely *behind* the rear spar. Moving the rear spar *forward* does impose a wing structural penalty. German reports, however, showed that the entire Arado System of supercirculation weighed no more than the fowler-flap-installation on the production model. The ONERA system may also suffer a structural penalty because of the complex flap and full internal chordwise flow.

As mentioned earlier, the ME-109 German fighter was modified with a high lift system. The system adapted was that of *blowing over the flap*, as illustrated by the previous smoke-tunnel photograph. Air for supercirculation was to be produced by two blowers located in the wings and driven by extensions from the

main power plant. The power plant was in this case a reciprocating engine. The ME-109 with this system installed was obtained by French authorities after the war. Only model tests of the ME-109 have been reported by ONERA. Fig. 15 illustrates the effect of such a supercirculation system on a complete airplane of a fighter configuration. This polar is for equilibrium conditions—i.e., sufficient tail load to overcome the diving moments have reduced the wing C_L's slightly, yet are considerably higher than the capabilities of flap alone. Therefore, these are actually usable C_L's. The coefficient C_μ employed in an all-blowing system was introduced by Poisson-Quinton of the ONERA and is defined as $C_\mu = (2Q_m v_j / \rho S v_0^2)$. For each value of C_μ, the polars shift toward the theoretical induced drag polar for the airplane. This, of course, reflects the thrusting component that is obtained from the blowing jet of air, as well as the drag reduction due to preventing separation of flow over the flap and wing proper.

I have been able to touch only briefly on some of the high points of boundary-layer control and supercirculation which affect the lift capability of fixed aircraft wings. The entire field has taken on new importance because of the need for methods of reducing landing and take-off speeds on our high-speed aircraft, without penalizing the high-speed performance. Because the jet engine may provide the necessary air pumping machinery, the practicability of boundary-layer control and supercirculation appears reasonable. Personally, I am convinced that the perfection of high lift systems, as have been presented here, will result in *the* better and safer aircraft we *all are* trying to achieve.

BIBLIOGRAPHY

Razak, K., Razak, V., and Bondie, R., *Wind Tunnel Investigation of a Method of Boundary Layer Control as Applied to a Reflection-Plane Model at Full Scale Reynolds Number*, University of Wichita, Report No. 032, June, 1951.

McLarren, Robert, *NACA Previews Tomorrow*, Aero Digest, September, 1952.

Rebuffet, P., and Poisson-Quinton, Ph., *Recherches sur l'Hypersustentation d'une Aile en Fleche Reelle par Controle de la Couche Limite Utilisant le Prelevement d'Air sur le Turbo-Reacteur*, La Recherche Aéronautique, O.N.E.R.A., pp. 39–54, March-April, 1950.

Stone, H., *Use of Boundary Layer Control with Rocket Induction Pumps*, Air Force Technical Report No. 6288, August, 1950.

Jousserandot, P., *The Application of Boundary Layer Control to a Model of a Complete Airplane by Means of a Blowing Apparatus on the Flaps and Ailerons*, La Recherche Aéronautique, No. 23, pp. 13–22, 1951.

Heinemann, E. H., *Airplane Weight and Cost Can Be Reduced*, Aeronautical Engineering Review, Vol. 12, No. 1, pp. 20-23, January, 1953.

Schweir, W., *Lift Increase Produced by Blowing on a Wing of a Profile Thickness of 9% Equipped with a Slot and Slotted Flap*, Institute of Aerodynamic Research, Göttingen, E.V.C.G.D-71.

Regenschiet, *Measurements Taken on a Suction Flap Wing with and Without Hinged Nose*, NACA 23015, Report No. 1312.

Poisson-Quinton, Ph., *Sur le miechanisme et l'application du controle de la couche limite aux avions*, Proceedings of the International Colloquim on Mechanics, Vol. II, Poitiers, 1950.

Prandtl, L., *Upon Fluid Motion with Very Small Friction*, Symposium of the 3rd International Mathematics Congress, Heidelberg, 1904.

Klass, Phillip, *Why So Many Missed ILS Approaches*, Aviation Week, ILS Article, pp. 35–39, August 25, 1952.

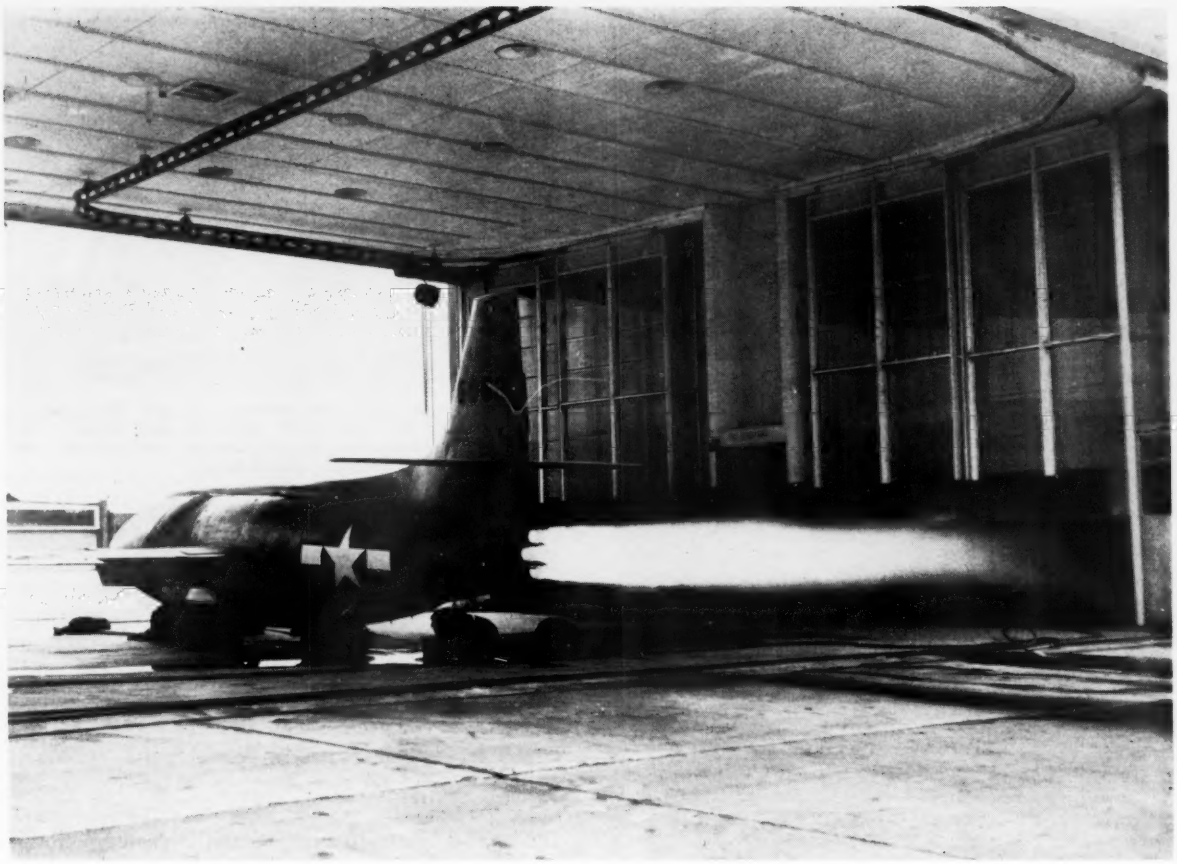
Special IAS Publications

	Member Rate	Nonmember Rate
Aeronautical Engineering Index – 1952	$ 3.00	$ 5.00*
1951	2.50	4.00*
1950, 1949, 1948, 1947 (each)	2.00	3.00*
Second International Aeronautical Conference Proceedings	15.00	17.50*
First Convertible Aircraft Congress Proceedings	3.00	5.00*
Second Convertible Aircraft Congress Proceedings	3.00	5.00*
Fifteenth Wright Brothers Lecture—The Experimental Approach to Aircraft Structural Research, P. B. Walker (Reprinted from the March, 1952, and April, 1952, JOURNAL OF THE AERONAUTICAL SCIENCES)	1.00	1.50
Sixteenth Wright Brothers Lecture—Technical Trends in Air Transport, William Littlewood (Reprinted from the April, 1953, JOURNAL OF THE AERONAUTICAL SCIENCES)	1.00	1.50
The Earth's Atmosphere, H. E. Roberts, including 20- by 16-in. colored chart (Reprinted from the October, 1949, AERONAUTICAL ENGINEERING REVIEW)	0.65	1.00
Books on Selected Technical Subjects in the IAS Library (up to 1950), unbound	2.00	2.00*

*Add $1.00 for orders outside the U.S.A.

These may be obtained by writing to

Publications Department, Institute of the Aeronautical Sciences, Inc., 2 E. 64th St., New York 21, N.Y.



First to crash through the sound barrier, the Bell X-1 fires its rocket motor, which weighs about 200 lbs. and can exert a thrust equivalent to 20,000 hp. at top flight speeds.

Jet Metals

WILSON G. HUBBELL*

Ryan Development Laboratories

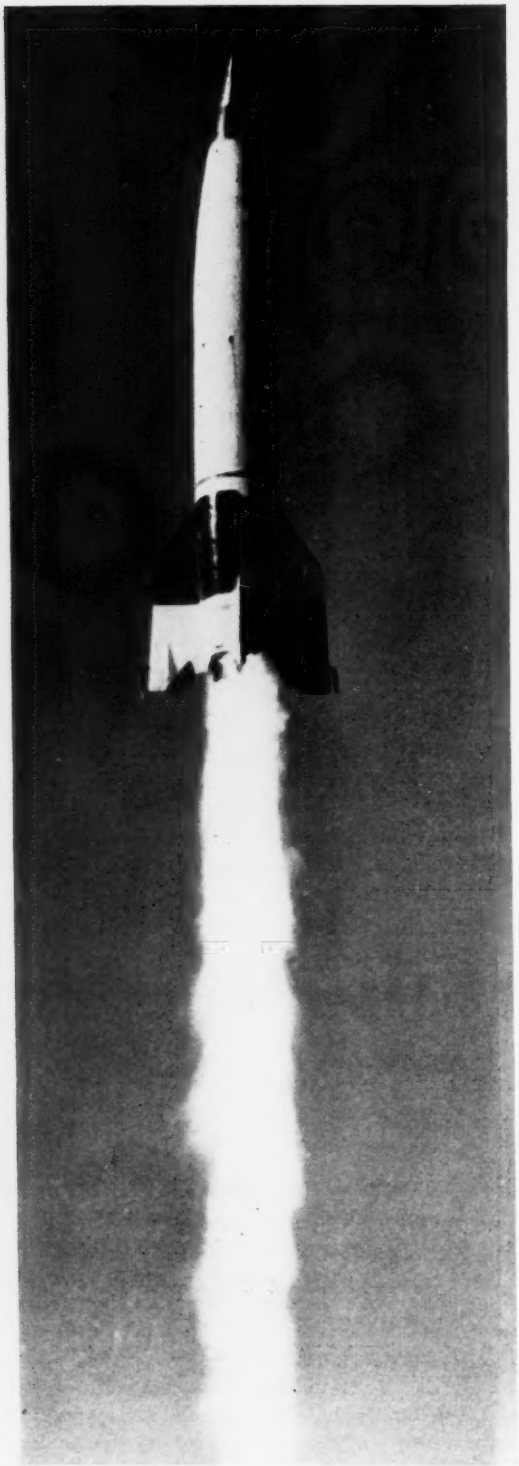
Introduction

Nothing has ever put the heat on metals like the jet engine. This era has already been labeled the "high-temperature age" because of the impact that this swirling inferno has exerted upon modern life. It is consuming undreamed of tons of hard-to-get alloys at an alarming tempo. Yet, in the metallurgist's mad scramble to feed its fires, the jet power plant provides a mighty incentive that is uncovering a wealth of knowledge about new metals and their unpredictable combinations.

From the birth of the universe until the 16th century, only seven metals were known and used by man: gold, silver, copper, tin, iron, lead, and mercury. These were found freest in nature. During the next three centuries, seven more metals were discovered. But in the last 50 years, scientists have unearthed 69 additional metals to bring the total to 83, or more than three-fourths of the 100 elements known to exist. Now, the searchlight of science is being turned on the one-third of these metallic elements which have been little more than laboratory curiosities.

Impetus for this metallurgical research is the pressing need for materials that can defy the consuming heat of shimmering jet engines, some of which can blaze away 2,000 gal. of fuel per hour. The Ryan Aeronautical Company is prominent in this quest because Ryan is an important producer of the "hot end" components of the nation's jet power plants. Rapidly becoming as familiar as the pistons and cylinders of the conventional engine, "hot end" parts are combustion chambers, exhaust cones, and afterburners of the jet engine.

* Chief Metallurgist.



Outward bound, the fearsome V-2 rocket trails a cometlike tail of flame. In 1 min. it consumes 9 tons of fuel and rockets to 3,500 m.p.h.

World's fastest aircraft, the supersonic Douglas Skyrocket, has probably ticked off 1,500 m.p.h. under the cool control of Bill Bridgeman, Douglas pilot. Mostly fuselage, with vestigial wings, the Skyrocket is a 15,000-lb. winged bullet.

The sudden emergence of the jet engine posed terrific problems in many fields of production because it is radically different from the piston-type power plant that is largely tailored from forgings and castings. The jet family of engines encompasses substantial proportions of high-temperature sheet metal structures.

With jet planes flying at supersonic speeds above 50,000 ft. in routine flights, the turbojet is already five times as powerful as the largest piston-engine-propeller drive, and its installed weight is less than one-quarter that of a piston engine of comparable power at high speed. Yet engineers declare that the potential of this infant prodigy has scarcely been tapped. Compact engines with power equivalent to 30,000 hp. are envisaged if temperatures and pressures can be increased, and that is where the metallurgist is pacing performance. New materials with prescribed high-temperature properties must be synthesized to meet the challenge.

What are the temperatures encountered in the jet engine? Highest readings are found in combustion chambers and afterburners where flame temperatures soaring to 3,700°F. have been tallied. Since this is 1,000 deg. hotter than the melting point of the alloys used in these structures, it is evident that wall temperatures are considerably lower than these figures. Actually the metals operate at temperatures within the range of 1,200° to 1,800°F. This disparity between flame and wall temperatures is accomplished by ingenious design innovations that ensure the centering of the combustion flames within the structures and provide a blanket of cooling air around each component.

Why are metallurgists facing a dilemma in finding alloys to withstand operating temperatures of 2,000°F. when a number of metals have melting points greatly in excess of this figure? For instance, tungsten melts at 6,200°F., molybdenum at 4,800°F., and columbium at 4,400°F. But melting point is not the important consideration in determining whether a metal can withstand the rigors of jet-engine environment.

The three characteristics that metallurgists search for in the heredity of a well-bred metal for high-temperature application are oxidation resistance, high-temperature strength, and corrosion resistance. Probably the most vital of these is the capacity to resist oxidation, because structural strength is useless if a

metal rapidly burns away. At jet-engine operating temperatures, ordinary steel burns like paper; and tungsten, molybdenum, and columbium oxidize quickly, as do most high-melting-point metals.

Oxidation Resistance

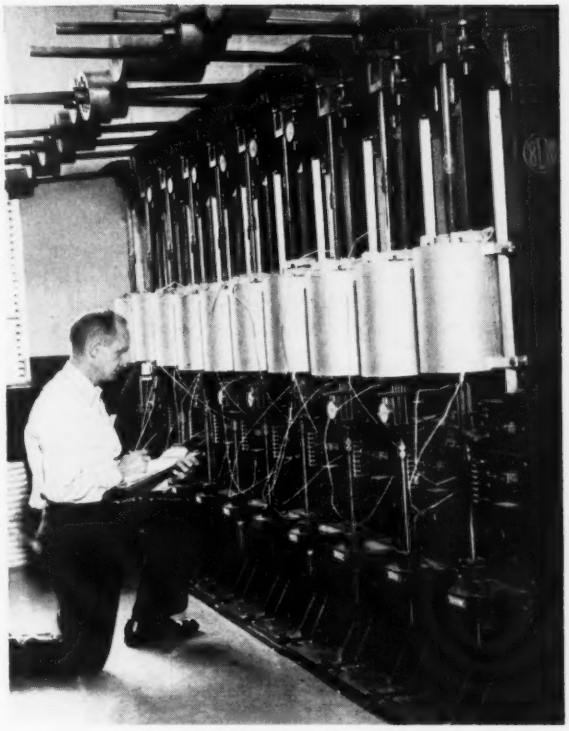
Ability of a metal to resist oxidation at elevated temperatures is largely determined by the type of oxide scale it forms. Laboratory investigations show that many metals form a tough, impervious scale that retards progressive oxidation. Others form a porous type of scale which continues to build up and flake away, eating into the metal. However, over prolonged periods of exposure, almost every type of oxide film tends to break down because of compressive stresses that are set up. The effects of repetitive heating and cooling cycles, experienced in jet-engine operation, cause compressive stresses in the oxide film because the underlying metal tends to contract faster than the oxide scale. Alloys having high coefficients of thermal expansion aggravate this condition because they exhibit greater dimensional change under varying temperature.

High-Temperature Strength

The second vital quality that a metal must possess for jet-engine use is good strength at high temperatures. This involves all kinds of strength exhibited by alloys, such as ultimate tensile strength, yield tensile strength, creep strength, and stress rupture strength. There is a striking difference in the behavior of metals at room temperature and in the torrid environment experienced in jet power plants. A good conception of this can be obtained when it is realized that structural carbon steel, with a room temperature strength of 140,000 lbs. per sq.in., would have an ultimate tensile strength of only 1,000 lbs. per sq.in. after exposure to 1,400°F. for 1,000 hours.

The design of load-bearing structures for service at atmospheric temperatures is generally based upon yield or tensile strength that is determined in ordinary room-temperature tensile tests. In service at ordinary temperatures, with a design stress determined in this way, a metal behaves essentially in an elastic manner. The structure undergoes an elastic deformation immediately upon application of the load, and no further deformation occurs with time. When the load is removed, the structure returns to its original dimensions.

At elevated temperatures the behavior is quite different. A structure will continue to deform with time after load application even though the design data may have been based upon tensile tests taken at the elevated temperature. This is due to the fact that tensile tests are relatively short-term affairs, accomplished within a few minutes. Under prolonged application of temperature and stress, metals tend to deform at a slow rate. This deformation is called "creep" and is expressed in terms of pounds per square inch required to produce an elongation of 1 per cent in 10,000 hours of exposure at the specified temperature. For jet engine parts, where precision and exact dimension are a necessity, high creep strength is of prime importance. Certain rotating structural members must have a creep strength that will resist a 1 per cent elongation in 100,000 hours of service, about 11 years.

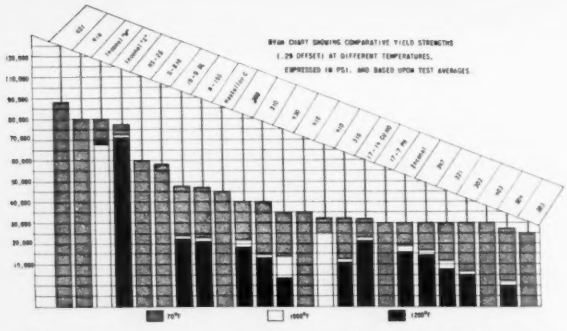


Creep test setup at International Nickel Company. Designed to find out how much heat and load a metal can sustain over a long period without stretching more than 0.1 per cent, creep test data are vital to jet research.

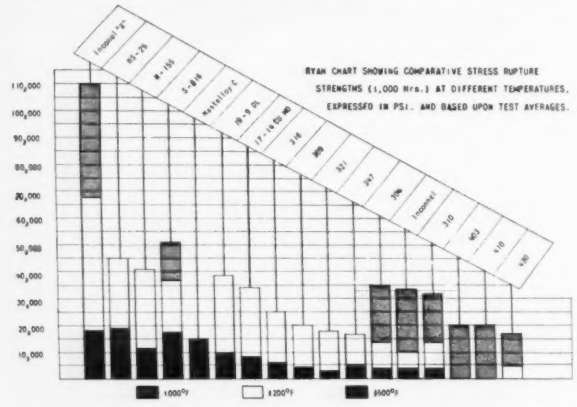
Creep of a metal under constant load and temperature occurs in three stages. First, the metal elongates rapidly but at a decreasing rate. In the second stage, usually of longer duration, the rate becomes constant. The third stage occurs when the elongation rate increases rapidly until the metal fails.

At the beginning of a creep strength test, the metal will exhibit an elastic extension before it starts to flow. Also, if the test is not carried to fracture, the metal will contract a similar amount when the load is removed. From these phenomena it is apparent that metals creeping under stress at high temperature possess both elastic and plastic properties simultaneously.

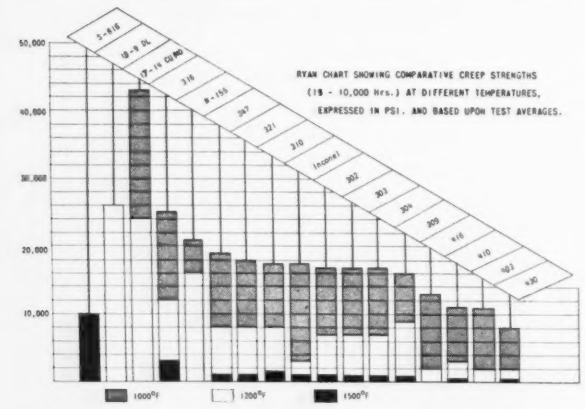
A metal will not stretch indefinitely without fracturing. Therefore, it is important to the designer of high-temperature components to know when a metal will rupture under conditions that produce creep. Since creep tests are usually long-term undertakings (some have been run for 10 years), another means has been evolved to disclose the stress rupture point of metals. Similar to the creep test, this test utilizes a greater strain than the creep test in order to speed up the elongation process. By extrapolation of creep and stress rupture test data, it is possible to determine when a metal will fail under prescribed conditions. This


RYAN CHART SHOWING COMPARATIVE YIELD STRENGTHS
(.2% OFFSET) AT DIFFERENT TEMPERATURES,
EXPRESSED IN PSI. AND BASED UPON TEST AVERAGES.

Ryan chart showing comparative yield strengths (0.2 per cent offset) of jet metals under varied temperature, expressed in pounds per square inch and based upon mean test averages.


RYAN CHART SHOWING COMPARATIVE STRESS RUPTURE
STRENGTHS (1,000 Hrs.) AT DIFFERENT TEMPERATURES,
EXPRESSED IN PSI. AND BASED UPON TEST AVERAGES.

Ryan chart showing comparative stress rupture strengths (1,000 hours) of jet metals under varied temperatures, expressed in pounds per square inch and based upon mean test averages.


RYAN CHART SHOWING COMPARATIVE CREEP STRENGTHS
(1% - 10,000 Hrs.) AT DIFFERENT TEMPERATURES,
EXPRESSED IN PSI. AND BASED UPON TEST AVERAGES.

Ryan chart showing comparative creep strengths (1 per cent for 10,000 hours) of jet metals under varied temperature, expressed in pounds per square inch and based upon mean test averages.

failure occurs at lower stresses than the ultimate tensile strength of the material.

Corrosion Resistance

The third characteristic that catches the eye of the high-temperature metallurgist is corrosion resistance. Corrosion is the destructive alteration of a solid body by chemical or electrochemical reactions arising on the surface. Usually metals are corroded by chemical solutions in which some of the positively charged ions in the solution lose electrical charges to the metal being corroded. The elevated temperatures concomitant with jet-engine performance amplify and accelerate the factors causing corrosion, which are products of combustion and atmospheric elements.

Fortunately, corrosion resistance is the least important obstacle to hurdle in the quest for high-temperature materials, because the elements that provide metals with good oxidation resistance also contribute to their capacity to resist corrosion. Chromium and nickel, present in almost all high-temperature alloys, contribute greatly to their resistance to both oxidation and corrosion. The only exceptions to this are the alloys in which carbide precipitation occurs under elevated temperature. In these metals a stabilizing agent, such as columbium or titanium, is added in order to prevent the formation of a harmful carbide network that could provide a path for intergranular corrosion.

Actually, oxidation is a specialized form of corrosion—a hot corrosion in which a black "rust" or oxide is formed rather than the familiar types of corrosion oxides that occur at normal temperatures.

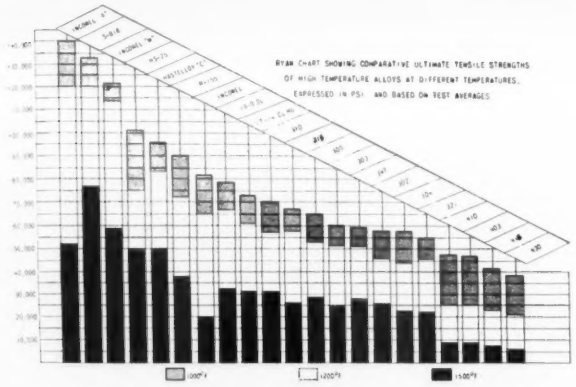
For years the Ryan Development Laboratories have worked closely with the steel mills in developing research data that would serve as a guide to the evolution of new alloys. Today, Ryan production is utilizing 21 high-temperature alloys in the fabrication of components for power plants. These metals may be classified into four groups: the chrome-nickel steels, chrome steels, nickel-base alloys, and cobalt-base alloys.

Chrome-Nickel Steels

The chrome-nickel steels contain these elements in approximately 18–8 ratios and are commonly referred to as austenitic steels. This description refers to their crystalline structure in which the ingredients are said to be in solid solution so that each crystal is composed of an intimate mixture of the constituents.

This group of steels is most widely used for high-temperature applications because of its good characteristics of oxidation and corrosion resistance and high strength at elevated temperatures. These steels have about six times the electrical resistance of ordinary steels and respond readily to welding techniques. However, since they expand 50 per cent faster and conduct heat only half as fast as plain steels, they require special care during welding to prevent distortion. They do not need heat treatment after welding to develop maximum physical strength.

They are nonmagnetic and cannot be hardened by heat-treatment. They may be hardened by cold working, and then they become slightly magnetic. Cold working enhances their structural strength at the cost of ductility. These steels are difficult to machine unless they contain added amounts of sulfur or selenium.


RYAN CHART SHOWING COMPARATIVE ULTIMATE TENSILE STRENGTHS
OF HIGH TEMPERATURE ALLOYS AT DIFFERENT TEMPERATURES,
EXPRESSED IN PSI AND BASED ON TEST AVERAGES

Ryan chart showing the comparative ultimate tensile strengths of jet metals under three varied temperatures, expressed in pounds per square inch and based upon mean test averages.

When subjected to temperatures above 800°F., they tend to precipitate carbides in their grain boundaries, lowering their resistance to corrosion. The corrosion resistance may be restored by heating them to 1,850–1,900°F. and cooling them quickly, or they may be protected against the formation of harmful carbide precipitation by the addition of columbium or titanium to their formulas.

From this group, Ryan builds a variety of jet- and piston-engine components. High-temperature exhaust systems for Douglas DC-6 and Convair 240 and 340 air liners are fabricated from 19-9DL stainless steel. Ryan-built aft frames and ceramic-coated combustion chambers for General Electric jet engines are made from 321. Huge exhaust systems for Pratt and Whitney R-4360, 3,500-hp. piston engines are built from type 310. For critical carburetor heat take-off tubes, in Continental tank engines, and turbosupercharger waste gate valves for Boeing C-97 Stratofreighters, Ryan uses Haynes Stellite N-155 alloy.

Normally, type 347 stainless steel is consumed in large quantities at Ryan because of its excellent qualities, but it has been temporarily supplanted by other types because of the scarcity of columbium. From type 316, Ryan makes complex case weldments for a new Pratt & Whitney jet engine. Various port flanges and other fittings for exhaust system equipment are fashioned from types 302 and 304, where the applications do not involve extreme temperatures, because these alloys are unstabilized. Where good machining is a requisite, type 303 stainless is employed.

Chromium Steels

The straight chromium steels, containing no nickel, are either martensitic or ferritic in crystalline structure, depending upon their hardening characteristics. Those containing up to 14 per cent chromium harden intensely if they are allowed to cool rapidly from high temperatures, forming a hard, relatively brittle substance called martensite. Because they respond to heat treatment, they are capable of being given a wide range of mechanical properties such as tensile strength, hardness, etc.

Those chromium steels containing from 17 to 30 per cent chromium do not respond to heat treatment or cooling and remain essentially ferritic at all times. The intermediate types, containing between 14 and 17 per cent chromium, behave in a manner that depends upon their exact chromium and carbon contents.

In the straight chrome group, corrosion resistance is a function of the amount of chromium dissolved in the iron. Chromium contents up to 4 per cent do not increase corrosion resistance. Amounts from 4 to 10 per cent improve resistance to corrosion appreciably. Chromium percentages from 10 to 30 per cent are designated when oxidation resistance at high temperatures is required.

The steels with chromium contents of from 5 to 30 per cent are magnetic in all conditions. They exhibit distinctly inferior creep resistance compared with the chrome-nickel stainless steels. The 17 per cent chromium steels have excellent oxidation and corrosion resistance and may be used at temperatures up to 1,500°F. The 25 per cent chromium content series is designed for severe heat and corrosion applications and is good for applications where temperatures reach 2,000°F.

All of the straight chrome steels are more difficult to weld than the chrome-nickel types because the welding heat leaves them in a brittle condition. They have about the same coefficients of expansion as ordinary steel, with several times the electrical resistance and slightly lower melting points. They tend to become brittle from welding heat in two ways—by slow cooling from around the 1,200°F. range and by grain growth produced by holding them over 1,650°F. The first type of embrittlement may be eliminated by quick cooling from above 1,200°F. The second type cannot be remedied but may be avoided by careful welding techniques.

From straight chrome steel, Ryan is building jet-engine case weldments and bearing housing assemblies for Pratt & Whitney jet engines. These are fabricated from welded alloys of type 410. Additional jet-engine detail fittings and components are built from type 416 and used in applications where temperature is not a critical factor.

Nickel-Base Alloys

The nickel-base alloys contain between 70 and 80 per cent nickel and cannot properly be called steels because of their small quantities of iron. In this group are Inconel, Inconel X and W, and Hastelloy C. These alloys have been tailored for high temperature and offer excellent oxidation and corrosion resistance at temperatures up to 2,100°F. Inconel is a wrought, nonmagnetic nickel-base alloy that does not lose its toughness or ductility because of internal structural changes, even after long exposure to high temperatures. It is particularly useful for service involving high temperature where

cyclic heating and cooling and large temperature gradients exist.

Inconel may be cold-worked, hot-worked, or forged without difficulty and can be welded and machined satisfactorily. Because of its advantageous properties, Ryan builds combustion chambers and transition liners for General Electric J-47 jet engines from this rugged alloy. Also, Douglas C-47 exhaust systems are fabricated from the same metal.

Inconel X was developed as a heat-treatable form of Inconel with vastly superior mechanical properties, particularly between 1,200° and 1,500°F. The 1,000-hour stress rupture strength of Inconel X is from four to six times that of Inconel in this temperature range, while its creep strength is from six to seven times greater. Above temperatures of 1,500°F., Inconel has somewhat better resistance to oxidation than Inconel X.

Inconel X is unusually strong at both ordinary temperatures and red heat and retains its strength beyond the drawing temperature for steels that are suitable for high-temperature use. Its special properties are achieved by heat-treatment rather than cold working. This is an advantage because greater uniformity of properties, from center to surface, may be obtained through heat-treatment than with cold working, which has more effect on the surface of the material.

Inconel X may be hot- and cold-worked satisfactorily. It requires annealing if shapes to be formed are deep. Machining Inconel X is satisfactory but more difficult than with Inconel. The alloy lends itself to all welding processes except gas welding, which requires special techniques.

Ryan builds large afterburner structures for General Electric J-47 jet engines and waste gate valves for turbo-supercharger-equipped C-97 Stratofreighters from Inconel X and Inconel W. Inconel W is similar to Inconel X in formula and behavior except that it contains no critically short columbium.

Another nickel-base alloy that is coming into greater use is Hastelloy C. This metal has substantial amounts of chromium and molybdenum as alloying elements. It is exceptionally strong and oxidation resistant at high temperatures up to 2,100°F. It has demonstrated successful performance in parts that are highly stressed or subjected to repeated thermal shock resulting from quenching at temperatures ranging from 1,600° to 1,800°F. It can be machined and welded satisfactorily and has fair forming characteristics. Afterburner assemblies are built from this specialized alloy.

Cobalt-Base Alloys

The cobalt-base alloys have been properly dubbed the "super alloys" because of the generous amounts of hard-to-get materials that they contain, such as tungsten, cobalt, nickel, and chromium. Because these alloys are expensive and often present fabrication obstacles, they are used in critical applications where their exceptional properties outweigh these other factors. Haynes Stellite No. 25 is used to build the eyelid assemblies used in the General Electric D-17 afterburners and the flame holders that are another part of the same structures. HS-25 has excellent strength and resistance to oxidation at high temperatures. It also exhibits good ductility and can be worked both hot and cold with a formability comparable to type 347 stainless steel.

Haynes Stellite No. 25 has an ultimate tensile strength of 155,000 lbs. per sq.in. and a yield strength of 70,000 lbs. per sq.in. Its stress rupture strength at 1,700°F. in 100 hours is 11,000 lbs. per sq.in. and 7,000 lbs. per sq.in. at 1,800°F. for 100 hours. It has good oxidation and carburization resistance for service up to 1,900°F.

These are the metals and alloys from which today's jet engines are built. Their behavior under extreme temperatures and stresses accounts for the amazing speeds and power which modern jet power plants are imparting to aircraft, missiles, and rockets. As this performance is stepped up in the inevitable march of science, new metals and alloys, not now conceived, will emerge from the metallurgical laboratory to assume these stellar roles.

Suggestion for Binding
Issues of the Aeronautical Engineering Review

Arrangements have been made so that our readers may have their issues of the Review bound carefully and economically in our authorized binding. Simply write for details to:

AIRE
P.O. Box 776
Highland Park, Illinois

Lockheed's Sky Sentry.

The Trend of Complete Aircraft and Guided-Missile Structures Toward Reinforced Plastics

WILLIAM E. BRAHAM*

Zenith Plastics Company

REQUIREMENTS FOR AIRCRAFT and guided-missile structures are becoming more complex as time goes on. The advent of sonic and supersonic high-altitude flight released a flood of design requirements that only a few short years ago were figments of the imagination of a few of our advanced-thinking scientists. To further complicate structural design, electronic equipment has been developed which is now as necessary to high-speed aircraft as the control column was to airplanes of World War II. The complexity of present-day military aircraft and guided missiles is such that, according to a recent report by the Aircraft Industries Association, 27 times more engineering man-hours are required to handle the design of airplanes of the comparable classes in production in 1945. This tremendous increase in the required engineering man-hours affects all other man-power requirements similarly—more mechanics, inspectors, stenographers, auditors, etc.—but the end product, when it leaves the ground, is an extremely efficient, although costly, machine.

This 27-to-1 ratio in the increase of engineering man-hours required to produce an aircraft today covers all phases of engineering. Structural design, stress analysis, weight analysis, and testing man-hours have increased proportionately to account for the heat problems of high-speed flight and to provide multipurpose structures—wings and fuselages which act as tanks, electronic insulators, armor-plate, and pressurized compartments.

Aircraft and guided missiles operating at speeds greater than Mach 1.0 develop external surface temperatures in excess of several hundred degrees Fahrenheit. During World War II, the Germans recorded temperatures of 1,500°F. on their V-2 missile. The effects of elevated temperatures on the metal alloys used in aircraft primary structures are well known and are recognized as detrimental to the efficiency and safety of the aircraft or guided missile. Improvements in

Presented to the New York Section, IAS, Bethpage, L.I., N.Y., May 19, 1953.

* Chief Engineer.

FIGURE 1

SPECIFIC ULTIMATE TENSILE STRESS VS. TEMPERATURE

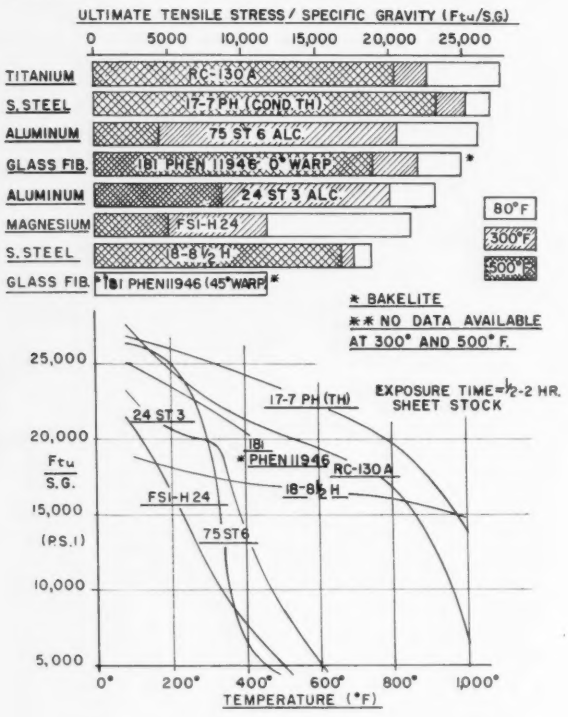


FIGURE 2 SPECIFIC TENSILE YIELD STRESS VS. TEMPERATURE

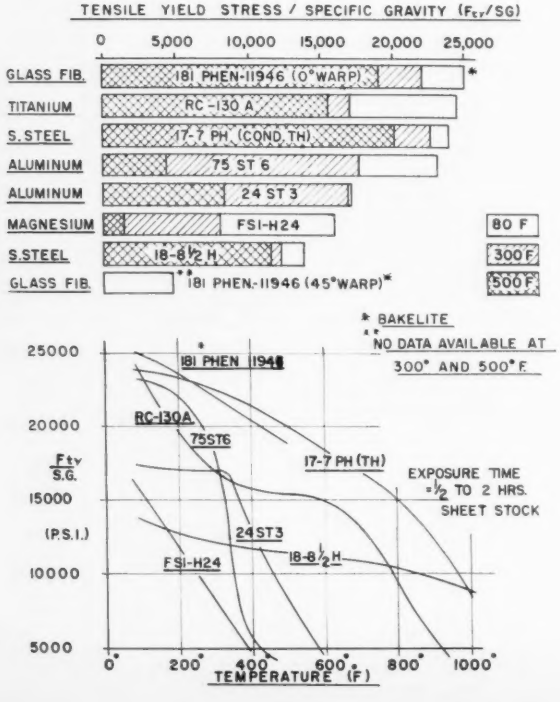


FIGURE 3

SPECIFIC COMPRESSIVE YIELD STRENGTH VS TEMPERATURE

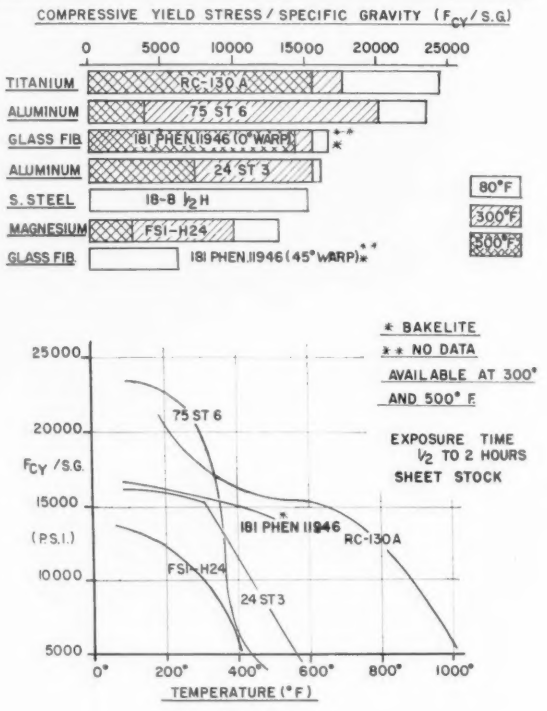


FIGURE 4- SPECIFIC COMPRESSION MODULUS VS. TEMPERATURE

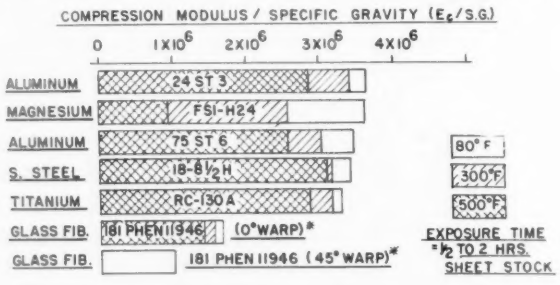
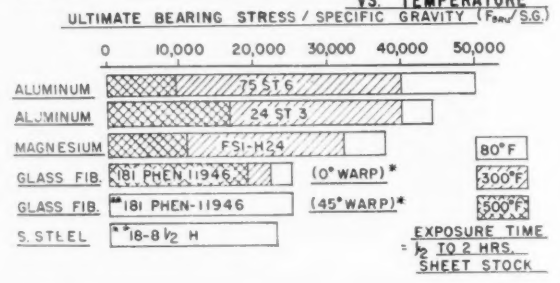


FIGURE 5- SPECIFIC ULTIMATE BEARING STRESS VS. TEMPERATURE



* BAKELITE

** NO DATA AVAILABLE AT 300° & 500°F

these metal alloys are required, or new materials usable for primary structures must be developed.

Members of the reinforced plastics industry working closely with air-frame manufacturers recognized this condition and began the development of materials that would be suitable for primary aircraft and guided missiles, particularly those operating above the speed of sound. Numerous laboratory tests have been conducted in Zenith Plastics Company Research Laboratories, as well as in the laboratories of some of the material suppliers. Some of the test results are compared with metals that have been accepted and used in the construction of aircraft and guided missiles. These comparisons are illustrated in Figs. 1–8. (In Fig. 1, these data illustrate the specific ultimate tensile stress—ultimate tensile stress divided by specific gravity of seven sheet materials and the variation of this property with temperature. By use of specific strength and moduli of elasticity, materials can be compared on an equal basis.)

A review of these data reveals that the strength properties of aluminum and magnesium sheet alloys fall off rapidly above 300°F. Above 300°F., the most promising materials appear to be titanium, stainless steel, and glass fiber phenolic laminate. In sheets of equal weight, glass fiber Bakelite phenolic laminates compare favorably with metal-alloy sheets on a stiffness basis, but the shear strength and modulus of the glass fiber Bakelite phenolic laminates are poorer than the metals. However, because of the inherent ease of constructing glass fiber sandwich components, this characteristic can be overcome.

The data shown for the reinforced plastic materials, the glass fiber Bakelite phenolic laminates, are for 181 cloth. There are values greater than those shown in these charts for combinations of 181 cloth and unidirectional glass fiber cloth (143), but space limitations prevent presentation of these data.

Over a period of 10 years, which is almost the entire life of the reinforced plastics industry, many advantages have been found in the use of reinforced plastic materials for high-performance aircraft and guided missiles. These materials are less expensive to mold and more easily produced in tapered thickness for aircraft structures than metals. They are easier to service and maintain in the field and more resistant to the corrosive effects of sea water, high humidities, aircraft fuels, hydraulic fluids, lubricating oils, and air at high temperatures. The tapered thicknesses that are required in most modern aircraft wings and tail surfaces can be produced from reinforced plastic materials with semi-skilled labor and inexpensive equipment. Molds and tools for forming the aircraft structures are less costly than equivalent tooling required to form metals. Less space and fewer complex assemblies are needed to produce a reinforced plastic structure, because component plastic parts can be easily bonded to their parent material under almost any atmospheric conditions, without the use of special equipment. These characteristics are reflected all through engineering and tooling,

FIGURE 6

SPECIFIC ULTIMATE SHEAR STRESS VS. TEMPERATURE

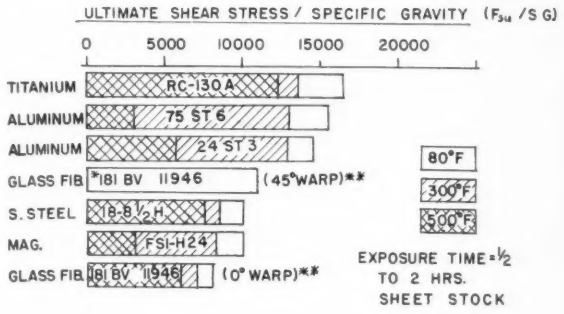
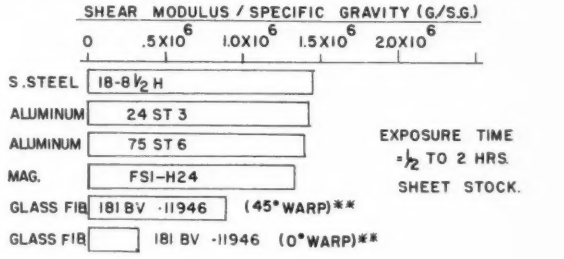


FIGURE 7

SPECIFIC SHEAR MODULUS AT ROOM TEMPERATURE

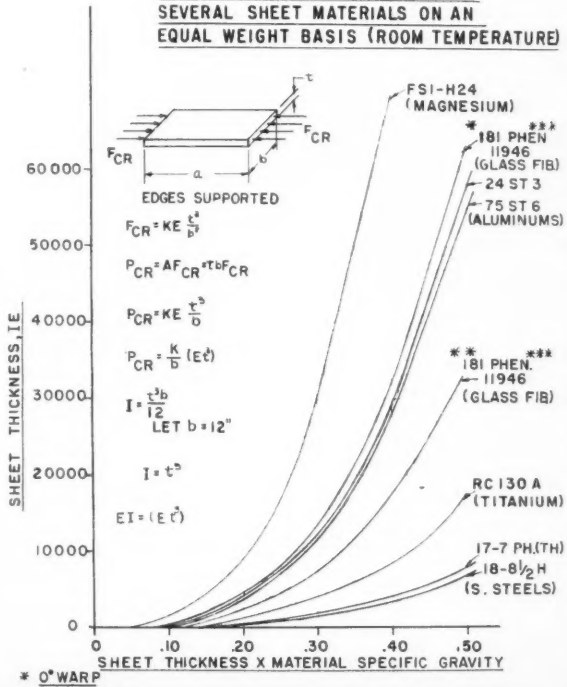


* NO DATA AVAILABLE AT 300° AND 500° F

** PHEN. BAKELITE

FIGURE 8

SHEET STIFFNESS COMPARISON OF SEVERAL SHEET MATERIALS ON AN EQUAL WEIGHT BASIS (ROOM TEMPERATURE)



* 0° WARP

** 45° WARP

*** BAKELITE

Convair's Sea Dart XF2Y-1.

with a result that only about 20 per cent of the engineering man-hours are required to design a reinforced plastic structure to meet the same specifications and requirements of a metal air frame, provided the engineer has adequate knowledge of plastic materials.

This great reduction in engineering man-hours has a large bearing upon the number of personnel required to perform the function of an air-frame factory. Production control, quality control, cost accounting, inspection, purchasing, and all direct labor operations are drastically reduced. In addition, the maintenance and servicing of aircraft in the field of operation is simplified.

Reinforced plastic materials—plastic resins impregnating glass fibers—found their way into aircraft in ducts, manifolds, and interior parts which could not be made economically from other materials about 10 years ago. The performance of these parts led to the use of reinforced plastics on an ever widening scale. Radar antennas had to be housed in radomes. Electronic requirements proved to be such that the most efficient, economical material to use was found to be reinforced plastics. Therefore, over a period of about 10 years, search domes and gun-laying domes were developed which utilized glass fiber cloth impregnated with polyester resins. For strength and weight requirements and for the best radar transmission efficiency, reinforced plastic honeycomb core materials were developed—also foam cores for gun-laying radar. Radomes have been designed for as much as 25 lbs. per sq. in. surface pressures, to withstand loads imposed by 2-in. hailstones at the cruising speed of the aircraft and to withstand the gunblast pressures of 20-mm. cannon. Aircraft designers no longer consider radomes as secondary structures, because in so many cases their damage or loss in flight could result in the loss or malfunction of the aircraft or missile of which they are a part.

Electronic requirements in several large bombardment-type aircraft have necessitated the use of reinforced plastic materials as part of the primary structure of the airplane. In some cases, almost entire sections of the aircraft are electronically isolated from the rest of the structure by using large reinforced plastic structures acting as insulators. In such cases, the bending, shear, torsion, and local loads are carried from the isolated metal structure that is serving as an antenna by the reinforced plastic structure to the rest of the airplane.

The actual number of reinforced plastic components which has been used successfully on an aircraft cannot readily be determined. However, it is estimated that Zenith Plastics Company has made 100,000 fin and wing tips—about 50 per cent of those used on military aircraft—and almost 75,000 radomes—about 60 per cent of those used on military aircraft of the United States. There have been practically no failures in service, other than those normally encountered in the life of an airplane. These parts and others are to be found in such aircraft as the Lockheed Neptune P2V and Super Constellation WV-2, McDonnell's Banshee and Demon, Convair's Sea Dart XF2Y-1, the F-80, F-84, F-90, F-94, B-47, B-52, B-36, and many other well-known aircraft.

At the present time, fuselage sections for a large airplane are being produced at the rate of two a day by Zenith Plastics Company. They are 17 ft. long, approximately 6 ft. high, and 3 ft. wide. No stringers, bulkheads, or rings are used in this structure. It is a monocoque honeycomb core structure that has withstood almost 300 per cent of ultimate design loads in static test.

Convair's Sea Dart XF2Y-1, the Navy's delta-wing water-based fighter, utilizes reinforced plastic parts that are subjected to high loads and elevated temperatures. The continuous exposure of this airplane to sea water and other extreme climatic conditions will again prove the advantages of reinforced plastic materials over other materials used in this airplane.

Lockheed's Super Constellation laboratory also illustrates the application of reinforced plastic materials to highly loaded important parts of a modern airplane. In the picture of Lockheed's Sky Sentry (see headpiece, page 37), which is a Super Constellation, similar to the U.S. Navy's new WV-2 radar plane, huge reinforced plastic parts can be seen. It is a well-known fact that this airplane cruises at a speed in excess of 300 m.p.h. The sharklike fin atop the fuselage is about 15 ft. long, 8 ft. high, and 5 ft. wide. The extended belly of the fuselage is approximately 29 ft. long, 20 ft. wide, and 7 ft. deep. *This is the largest air-borne radome ever built.* The tanks on the wing tips of this airplane are used to carry extra fuel and are similar to tanks now being developed for future production to supply the U. S. Air Force. The use of reinforced plastic materials for such tanks provides the advantages of low cost and the use of noncritical materials that cannot be re-used, should they fall after being jettisoned from our aircraft over enemy territory.

The reinforced plastic parts shown on the Super Constellation and those used in Convair's Sea Dart and in numerous other aircraft are indications of things to come, directly stemming from present-day manufacturing, design, and thinking. Future designs—those

(*Concluded on page 45*)

Optimum Exit-Nozzle Performance for Jet Engines

A Discussion of Development Experience and Design Problems Associated with Several Types of Variable-Area Exit Nozzles

RICHARD G. LAUCHER* and JOHN S. WINTER†

Marquardt Aircraft Company

ABSTRACT

The use of a variable exit nozzle on a turbojet engine will improve the performance of the engine, and it is required for adequate control of a turbojet when it is augmented by afterburning or water injection.

Of several variable-area nozzle configurations investigated—the clamshell, plug, flap, three-segment, and iris types—the iris-type nozzle exhibited the optimum characteristics. The iris-type nozzle has been found to have a nozzle efficiency comparable to that of fixed nozzles and is, therefore, considered a practical solution to the problem of control of variable exit area for turbojet engines.

INTRODUCTION

IN THE PRESENT STAGE of design and development of turbojet engines, it is generally recognized that exit-nozzle area control is required in order to achieve optimum performance.

In particular, where afterburning or water injection is used for thrust augmentation, a variable exit nozzle is necessary to provide the desired turbine temperature and pressure conditions under both normal and augmented engine operation.

Many additional advantages can be gained by equipping the engine with a variable-area exit nozzle. The use of such a nozzle will permit the maximum thrust to be obtained from the engine for take-off, independent of ambient temperature, since the nozzle can be varied to obtain maximum turbine temperature. It will permit maximum power to be drawn from the engine over the wide range of engine inlet conditions arising from present-day airplane operational speeds and altitudes. It is also possible to obtain more rapid changes in thrust in an emergency such as a carrier wave-off. With the fixed-area exit nozzle, increased thrust is obtained by increasing engine r.p.m., and a considerable time interval is required to accelerate or decelerate the engine because of the high inertia of the rotor. The pilot of a carrier-based aircraft should, therefore, find the variable nozzle valuable during carrier approach and landing, where he could use the nozzle to reduce his thrust as much as 50 per cent while maintaining full engine r.p.m., and a reduction of the jet nozzle area would provide an immediate increase in thrust in an emergency without the relatively slow acceleration of the turbojet rotor. In many engine configurations, it may be possible, through the use of a variable-area exit nozzle, to achieve an improvement in specific fuel consumption at cruising thrust. Another condition that might be alleviated is the combustion blowout that is encountered with a fixed exit-nozzle engine when it is operated with reduced thrust at high altitude. Other advantages of the variable-area exit nozzle include cooler engine starts, more rapid acceleration to operational engine speed, and compensation for thrust variations between individual engines in a multiengined aircraft.

The variable-area exit-nozzle design was undertaken in connection with the development of afterburners for turbojet engine thrust augmentation. This paper presents a brief description of several exit-nozzle configurations and a discussion of the design problems and performance of the iris-type exit nozzle selected as optimum.

FACTORS INFLUENCING NOZZLE DESIGN

In considering the methods of varying the exit-nozzle area, the following factors must be taken into account.

Internal Efficiency.—From the standpoint of internal efficiency, a variable type of exit nozzle which most closely approximates that of a fixed conical converging nozzle will give the optimum performance for the range of pressure ratios used in present production turbojet engines.

Jet Shape.—With respect to jet shape, a circular cross section would be desirable. Although it has not been proved that the internal efficiency will be less than that of a circular jet, a noncircular jet might result in buffeting of airplane structures in some airplane applications or in jet wake interferences in the case of dual installations.

External Profile.—In consideration of the aerodynamic problem of fairing the engine into an airplane, the exit nozzle should have the smallest possible external diameter. The adaptability of the profile to efficient ejector cooling design is also important in many installations.

Mechanical Problems Concerned with Serviceability.—From a mechanical standpoint, the exit nozzle should be simple; it should be structurally sound, light in weight, resistant to augmentation temperature, have reasonable actuation forces; and it should be fail-safe.

Presented at the Propulsion Session, Annual Summer Meeting, IAS, Los Angeles, July 15–17, 1953.

* Afterburner Section Supervisor.

† Afterburner Project Engineer.

FIGURE 1

PLUG TYPE NOZZLE

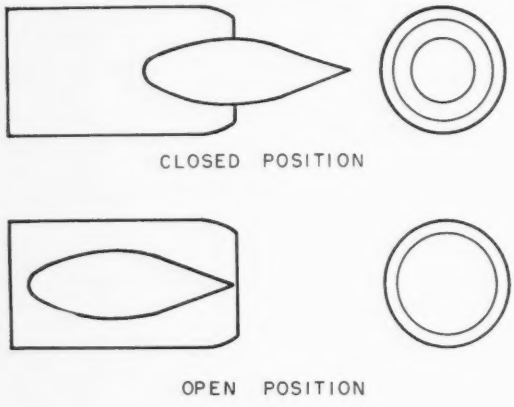


FIGURE 2

FLAP TYPE NOZZLE

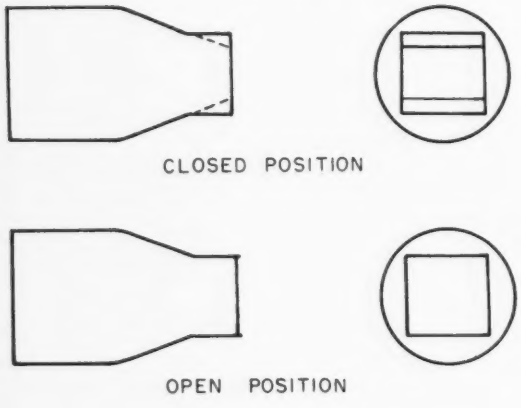
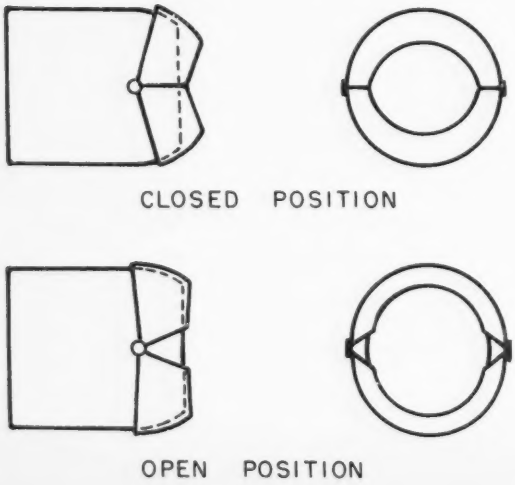


FIGURE 3

CLAMSHELL TYPE NOZZLE



Selection of a Nozzle Configuration

In the development of a variable exit nozzle for afterburners, five exit-nozzle configurations were studied. These were the plug type, the flap or door type, the clamshell or eyelid type, a three-segment type, and the iris type, which was finally selected as the most practical configuration.

The plug-type exit nozzle shown in Fig. 1 combines good internal efficiency with mechanical simplicity and the best external profile. However, the excessive nozzle length required for large area variations, the afterburner combustion chamber blockage, and the problem of extreme high temperatures on the plug and actuator mechanism eliminated further consideration of this configuration for application to an afterburner.

The flat-type exit nozzle shown in Fig. 2 also appeared to provide mechanical simplicity and fair internal efficiency. Upon further investigation of this type, it was found, however, that the large flat plate areas under high pressure loading and high temperatures, the high actuation loads, the sealing requirements, and the poor external profile presented major design problems.

The next type studied was the familiar clamshell or eyelid exit nozzle shown in Fig. 3. This type was selected as the initial nozzle to be constructed and tested since (1) it provides a large area-change ratio; (2) the mechanical design is simple, and it has a minimum number of parts; (3) the actuating forces are low; and (4) it is easily manufactured.

In static tests of the first afterburner equipped with this clamshell exit nozzle, the eyelids warped and bent severely during afterburner operation and considerable gas leakage occurred with a consequent high internal loss. These tests emphasize the disadvantages of the clamshell exit nozzle which are considered to be the following:

(1) It has a noncircular and nonplanar exit opening.

(2) It is difficult to seal to the combustion chamber and between the eyelids because of warping and nonsymmetrical loads.

(3) A large external diameter is required for eyelid clearances and structure, and, thus, the configuration is not readily adaptable to a smoothly faired ejection cooling shroud.

Although it was recognized that the first two disadvantages could probably be overcome by further development, design studies of other configurations were pursued.

In an effort to obtain a design that would not have the undesirable problems of a clamshell-type exit nozzle, a three segment nozzle of the type shown in Fig. 4 was investigated. Although this configuration was only adaptable to a two-position nozzle, it was considered better suited to positive sealing in the nonafterburning or closed nozzle position of the engine; it was less critical to warping; it would maintain a circular jet opening; and it was more adaptable to ejector cooling shroud design.

As a next development step, a design study of a multisegment nozzle effecting area change through iris-like movement of the segments similar to that shown in Fig. 5 was made. The study indicated that, although this type gave the impression of mechanical complexity, it offered the possibility of a practical and optimum solution to the problem. The iris-type nozzle has the following advantages:

(1) Its internal efficiency approaches that of a fixed nozzle in all positions.

(2) A circular jet opening is maintained in all positions.

(3) Good sealing against gas leakage can be obtained by bellows seals between the nozzle segments.

(4) A higher thermal distortion per segment can be tolerated.

(5) The external profile is a minimum diameter, and it is adaptable to ejector cooling design.

On the other hand, it has the following disadvantages:

(1) It has a multiplicity of parts.

(2) The actuating forces are high.

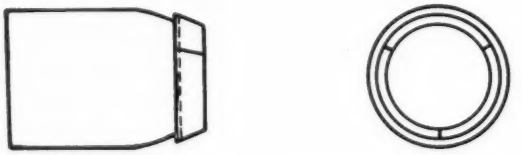
Since it was believed that the desirable features of the iris nozzle outweighed its mechanical problems, the design and construction of a nozzle of this type were expedited. In consideration of the fact that the trend of afterburner development at this time required a multiposition exit nozzle in place of a two-position nozzle, the three-segment type of design was set aside in favor of the iris nozzle.

Mechanical Design of the Iris Nozzle

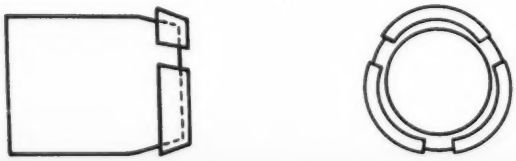
As is shown by Fig. 6, the present iris-type, variable-area exit nozzle consists of a large number of precision cast segments, each hinged to a supporting ring and attached to each other by bellows-type seals. These seals permit circumferential movement of the segments relative to each other as the nozzle area is changed. Expansion or contraction of the nozzle is effected by fore and aft movement of a "unison ring" or similar structure which is attached to the nozzle segments through cams and rollers.

FIGURE 4

THREE-SEGMENT TYPE NOZZLE



CLOSED POSITION



OPEN POSITION

FIGURE 5

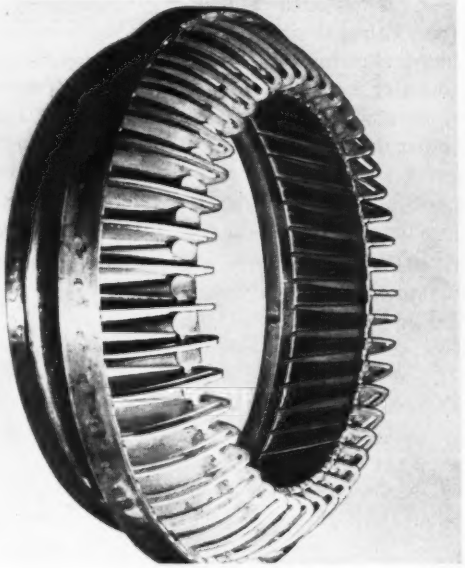
IRIS TYPE NOZZLE

CLOSED POSITION

OPEN POSITION

FIGURE 6

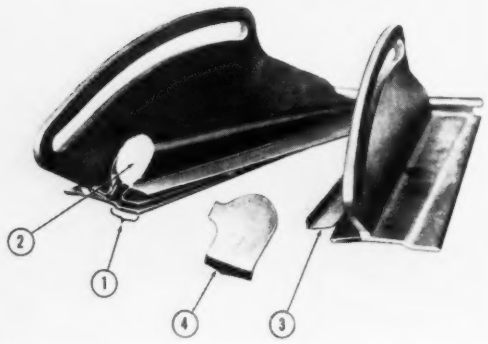
VARIABLE AREA NOZZLE



The primary problems to be overcome in the design of the iris nozzle were to provide an effective seal between the nozzle segments and to determine the method of actuation. The more difficult problem appeared to be the method of sealing between the nozzle segments.

Initially, the sealing effect of the internal pressure on overlapping nozzle flaps was considered. It was found, however, with this pressure sealing method that (1) friction forces would be high; (2) it would be necessary to maintain extremely close tolerances in the actuator mechanism to prevent separation of the seals; and (3) any warping of the edges would prevent good sealing. Since positive sealing against leakage was desired, the pressure sealing idea was discarded.

FIGURE 7
SEGMENT-SEAL ASSEMBLY



The sealing means finally adopted for intersegmental use is the bellows-type expander assembly illustrated in Fig. 7. It was considered desirable to use as large a number of segments as practicable to minimize the deflections and size of each bellows element. This arrangement has an accompanying advantage inasmuch as the width of the individual nozzle segments is thereby reduced, allowing the segment hinge lines to approach collinearity with the circular hinge line. By using these very short arcs in the segment hinge, there is no need for other than the optimum circular shape for the hinge ring. In addition, the narrow nozzle segments thus obtained are adaptable to close-tolerance casting techniques for quantity production.

In the initial test unit, the nozzle was constructed without the protector flap, the fiber glass plug, the flame shield, and the end plate shown in Fig. 7. The bellows elements were made of thin, Type 347 stainless steel, and they were spot welded to the nozzle segments. Upon testing, however, it was found that the turbulent area inside the bellows acted as a flame holder during afterburner operation and quickly burned out the bellows. Consequently, a configuration with protector flaps on the segments, fiber glass plugs in the bellows, and end plates was adopted so that the open area in the bellows was a minimum and the flow of jet gases was inhibited.

Under the test conditions for this modified test unit, the nozzle exhibited a fair endurance, averaging approximately 55 hours of engine operation of which 5 hours were run with the afterburner operating. The failures were all due to bending fatigue, and they occurred in the bellows base radii. Upon investigation, it was determined that a temperature of 1,600° to 1,800°F. occurring at the bellows base radii was contributing to the early failure. This condition was alleviated by providing flame shields at the radii as shown by Part 3 of Fig. 7. The bellows material was changed to a high-temperature-type alloy, and further operational and component tests have indicated that this nozzle seal design will now satisfy engine qualification test requirements.

The nozzle segments are cast from Type 310 stainless steel. Each segment incorporates a vertical web that serves to stiffen the segments, to transfer the heat from the nozzle surface, and to carry the cam slot.

The nozzle hinge shown in Fig. 7 rotates in a socket-type hinge ring. Inconel tape $^1/_{16}$ in. thick is used in the hinge ring to assist in sealing against leakage. The cam surface loading is designed so that the tape is always compressed by internal gas pressure.

Returning to the primary design problems, two types of actuating systems appear to be feasible for an iris nozzle. The first system utilizes coordinated radial movement of the individual nozzle segments. The second system employs a "drawstring" arrangement to exert circumferential force.

The first method of actuation was selected because it affords positive nozzle control for both opening and closing and because the loads on the components are lower.

Detailed studies of various mechanisms for actuation of this nozzle led to use of the cam and roller system shown in Fig. 6. As has been mentioned, the cams are cut into the vertical stiffening webs of the nozzle segments. The shapes of the cam slots are designed to keep the actuator forces as nearly constant as possible in all nozzle positions. Under this condition, the nozzle area change is approximately twice as great for a given axial displacement of the unison ring at the full-open-nozzle end of the travel as it is for the same displacement at the closed-nozzle end of the travel. This variation in nozzle movement rate has a beneficial effect upon the problems of nozzle control, since the engine and afterburner combination is approximately twice as sensitive to nozzle area changes when operating without afterburning as when it is operating with afterburning. In this manner, the relationship between the turbine out temperature change and the actuator movement is maintained approximately constant throughout the range of control of the nozzle.

The rollers are carried on a fore and aft moving "unison" ring. In the preliminary nozzle units, the unison ring was operated by four push-pull flexible cables attached from the ring to a single actuator. A system of push-pull rods would have been satisfactory but somewhat more complex and bulky.

A variation of the unison ring method of actuation is a design in which the cam rollers are built directly into the surrounding ejector cooling shroud. The shroud would then be moved fore and aft to expand or contract the nozzle. This arrangement would give obvious advantages such as greater simplicity, lighter weight, smaller overall diameter, and more even actuating load distribution.

Conclusions

In conclusion, the nozzle design and development discussed in this paper indicate that the iris-type exit nozzle is a practical design for optimum nozzle performance.

It is believed that the following advantages of the iris nozzle design far outweigh the disadvantage of mechanical complexity.

(1) It has a high internal efficiency comparable to that of a fixed conical nozzle.

(2) It retains a circular and concentric jet opening throughout its travel.

(3) It has an external profile readily adaptable to ejector cooling shroud or fairing designs.

(4) It gives good service under the extreme temperatures of afterburning operation.

(5) With bellows seals, it has no leakage of jet gases throughout its range of opening.

(6) The basic segment can be precision cast for production in quantity.

The Trend of Complete Structures Toward Reinforced Plastics

(*Concluded from page 40*)

with more complex requirements than these aircraft—can take advantage of the new phenolic resins and their valuable characteristics. It is anticipated by many that, in the near future, supersonic aircraft and guided missiles will utilize these new materials for primary structures in combination with metals and other materials to provide our services with safe, efficient, and more economical equipment.

Sherman M. Fairchild Publication Fund Papers

No.		Member Price	Non-member Price
FF-8	Compressive Buckling of Plates Due to Forced Crippling of Stiffeners, **Parts I and II**—P. P. Bijlaard and G. S. Johnston.	$1.30	$2.00
FF-7	Natural Flight and Related Aeronautics—James L. G. Fitz Patrick.	$2.65	$3.50
FF-6	Wetted Length and Center of Pressure of Vee-Step Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-5	Symposium on Standardization in Technical Information Services for Government Contractors.	$1.00	$1.00
FF-4	Finite Deflections of Curved Sandwich Plates and Sandwich Cylinders—F. K. Teichmann and Chi-Teh Wang.	$0.50	$0.85
FF-3	The Penetration of a Fluid Surface by a Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-2	A Study of the Flow, Pressures, and Loads Pertaining to Prismatic Vee-Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
AHS-1	Helicopter Flight Research at NACA, Langley—Jack P. Reeder.	$0.35	$0.75
286	Linearized Treatment of Supersonic Flow Through Axi-Symmetric Ducts with Prescribed Wall Contours—Charles E. Mack, Jr., and Ignace I. Kolodner.	$0.75	$1.25
244	Wetted Area and Center of Pressure of Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
229	Wave Profile of a Vee-Planing Surface, Including Test Data on a 30° Deadrise Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
168	Wave Contours in the Wake of a 20° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
166	An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
165	Theory and Practice of Sandwich Construction in Aircraft (A Symposium).	$1.85	$2.50
164	Applications of the Theory of Free Molecule Flow to Aeronautics—Holt Ashley.	$1.15	$1.50
106	Measurement of Ambient Air Temperature in Flight—W. Lavern Howland.	$0.35	$0.50
104	Tensor Analysis of Aircraft Structural Vibration—Charles E. Mack, Jr.	$1.85	$2.50
102	Electrical Resistance Strain Gages Applied to Wind-Tunnel Balances—Elmer C. Lundquist.	$0.60	$0.80
101	Introduction to Shock Wave Theory—J. G. Coffin.	$2.65	$3.50
100	Blade Pitching Moments of a Two-Bladed Rotor—R. W. Allen.	$0.75	$1.00
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kangas, and G. L. Pigman.	$0.75	$1.00

Papers should be ordered by number from:

Publications Department, Institute of the Aeronautical Sciences, Inc.

2 East 64th Street, New York 21, N.Y.

Structural Comparison of Perforated Skin Surfaces with Other Means of Effecting Boundary-Layer Control by Suction*

CHARLES B. CLIETT†
Mississippi State College

SUMMARY

The results of a series of studies to determine the structural feasibility of perforated sheet materials, which could be used as a means of effecting boundary-layer control by suction, are presented. These results include the ultimate tensile and shear strengths of perforated plywoods, the ultimate tensile and shear strengths of perforated 24ST-3 aluminum-alloy sheet, and the flexure-fatigue strength of this perforated aluminum-alloy sheet.

Empirical methods of predicting ultimate failure in tension and shear for these perforated materials have been found. A comparison between predicted results by these empirical equations and actual experiment has been made, and good agreement is shown to exist.

From the structural point of view, a comparison of this means of effecting boundary-layer control by suction is made with other methods and materials previously advocated.

INTRODUCTION

THE PROBLEM OF STABILIZING a laminar flow over a surface has been the subject of a large amount of theoretical research. Long before the first flight by man, this subject was receiving the attention of some of the best research scientists. The first recorded recognition of the inherent instability of flow over a surface where discontinuities exist in the velocity was published in 1845.[1] As early as 1904, Prandtl[2] recognized the possibility of influencing the boundary layer by suction. Since that date considerable aerodynamic research has been conducted along these lines, but little progress toward actual application has been made. The structural side of boundary-layer suction has caused considerable concern but has been the subject of little research. This paper is an effort to fill a small portion of the gap between the progress made on the aerodynamic considerations and the lack of progress made, because of little effort, on the structural considerations. A second purpose, and the more important one, is to stimulate the interest of structures-minded people and, therefore, lead to serious study of the subject.

Aerodynamic Considerations

The first method advanced for controlling the boundary layer by suction was by the use of single or multiple slots. Many papers have been published dealing with this process of control. Among the more important is one by Pfenninger,[3] who reported the use of a series of spanwise slots spaced along the chord from the leading to the trailing edge. Each slot was connected to an individual chamber through which the air was sucked. The individual arrangement made possible some saving in suction power since the suction flow required of such an arrangement varies with the position along the chord. Including the power lost by suction, he found drag reductions of from 33 to 50 per cent. The range of low drag coefficient more than doubled, and the glide ratio was 1/200. These are the results of tests made at a relatively low Reynolds Number. Tests at a higher Reynolds Number failed to show such favorable results. This, Pfenninger attributed to an increase of tunnel turbulence at higher velocities.

Airfoils especially designed for boundary-layer control by suction through slots have been advocated by Griffith. These were discussed extensively by Goldstein[4] in his Wright Brothers Lecture. The basic idea involved is that of producing a favorable pressure gradient over the entire region from the leading to the trailing edge. Many difficulties have been encountered during experimental procedures, but this method may well prove significant in the future.

In considering the design of a boundary-layer control system, it is important to maintain a laminar flow up to each slot, for, if the flow becomes turbulent, a great amount of suction is required to remove the turbulent boundary. For this reason there exists a critical spacing of slots which is less for the higher Reynolds Numbers than for the low Reynolds Numbers.

A boundary-layer stabilization method that offers near infinitely close spacing of suction sources is the porous area suction method. In addition to fulfilling the demands for stabilization at high Reynolds Number, this method also reduces the destabilizing influences of surface defects, of foreign particles adhering to the wing, and of surface waviness. A porous material has the advantage that it provides stabilization of the laminar boundary with the least sensitivity to disturbances. However, unless the porosity is made variable according to the local requirements along the chord, a large power expenditure for suction will be required. A possible solution is to divide the suction area into smaller areas, each of which has a separate suction pressure. This method, however, complicates the control of suction pressure, as well as the internal wing structure.

Perforated surfaces, consisting of closely spaced holes running spanwise in rows spaced the critical distance apart, offer a possibility of controlling the po-

Presented at the Motorless Flight Session, Twenty-First Annual Meeting, IAS, New York, January 26–29, 1953.

* This work was carried out as part of an Office of Naval Research contract conducted by the Engineering Research Station of Mississippi State College.

† Assistant Professor of Aeronautical Engineering.

rosity by the size of the holes and by their spacing chordwise and spanwise. In the research reported in reference 5, the laminar boundary layer was maintained to the trailing edge on the top surface of a classical airfoil with exceedingly small suction power.

Structural Considerations of Various Methods of Suction Boundary-Layer Control

The use of multiple slots as the mode of suction for boundary-layer stabilization would present several structural difficulties. The problem of torsional stability would of necessity have to be solved by an entirely new process. Since the suction power required varies along the chord, individual compartments with separate internal pressures would be needed to keep the power requirement low so that an overall efficiency gain could come from the boundary-layer stabilization. The interior of the wing would then become a series of individual compartments critical in design because of the duct loss factor. Because of the many cutouts and sharp bends that would be required, the fatigue problem would also become critical. With these thoughts in mind, it would seem that any design capable of meeting the aerodynamic requirements should result in a strength-weight ratio so low that the use of this method of stabilization is hardly practical. It is the author's opinion that use of multiple slots is not feasible without a serious weight penalty. Single slots, such as those used near the trailing edge, could be handled successfully.

Porous metals (like sintered bronze)[6] which have been recently developed offer little hope of becoming structural materials for aircraft. They are not only heavy but have very low strength. Sintered bronze cannot be machined if it is to be used for suction because the pores fill readily. Although the porosity can be changed by manufacturing procedures, it presently cannot be controlled within practical limits. For model purposes its strength is probably sufficient, but in actual application it would probably be merely excess weight added to the structural components of a wing.

Perforated sheet materials have this structural advantage over slots: Torsion can be carried by the sheet. Since the use of many separate chamber pressures can be eliminated by varying the porosity, an additional advantage in structural simplification results. In fact, the technique of laminar boundary-layer stabilization using a perforated surface may involve little additional structure over the conventional airplane wing design.

The use of double skin surfaces with a relatively small air space between these surfaces would make possible easy adaptation of existing aircraft for boundary-layer control, if the control is applied through perforated sheet materials. (See Fig. 1.) Since this structural condition is used on some of our current aircraft, they can be adapted for early study and application of boundary-layer control with a minimum of structural revision. It is for these reasons that this research on

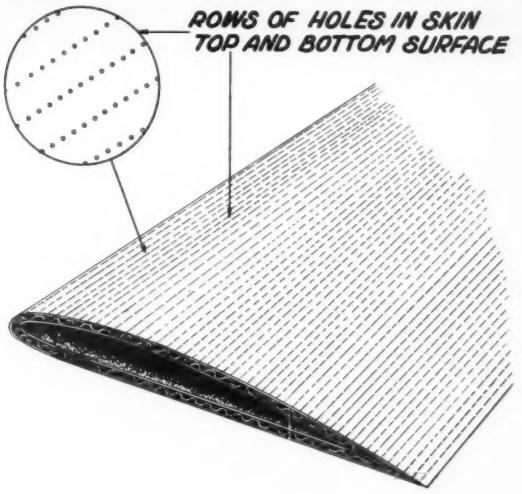


FIG. 1

TYPICAL WING SECTION SHOWING HAT SECTIONS USED AS DUCTS FOR SUCTION AIR

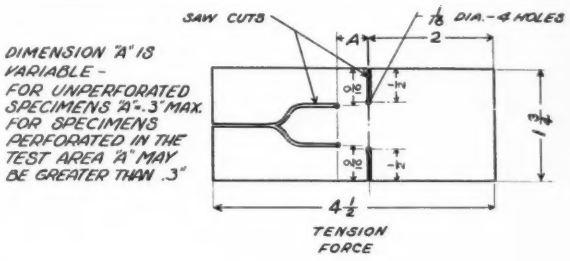

SAW CUTS
1/8 DIA.-4 HOLES
A
2
DIMENSION "A" IS VARIABLE - FOR UNPERFORATED SPECIMENS "A"=.3" MAX. FOR SPECIMENS PERFORATED IN THE TEST AREA "A" MAY BE GREATER THAN .3"
3 1/2
4 1/2
TENSION FORCE

FIG. 2

SHEET ALUMINUM TENSION TYPE SHEAR SPECIMEN

the structural properties of perforated sheet materials was undertaken.

Structural Properties—Perforated Sheet Materials

The design of all test specimens and the testing procedure conformed to the standards of the American Society for Testing Material[7,8] for all cases for which standards have been established. The tension-type shear specimen of the ASTM was used to determine the shear properties of both the perforated and unperforated plywood specimens. Since no standard exists for similar tests on aluminum sheet materials, it was necessary to design a specimen for these tests. The specimen as designed is shown in Fig. 2. The aluminum fatigue specimen was designed such that, when perforated, the test section remained three dimensional rather than just a single failure cross section.

In all comparisons of predicted ultimate failure loads and experimental ultimate failure loads, the predicted ultimate failure loads were calculated from the prob-

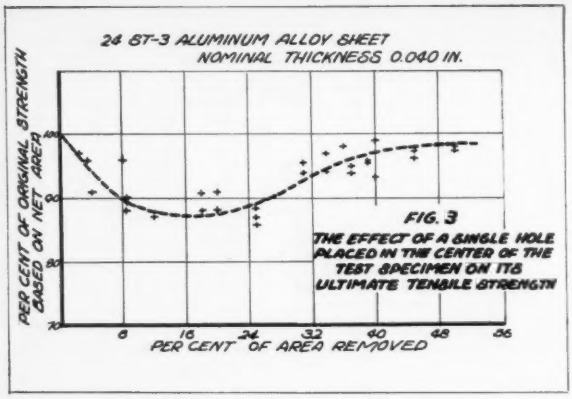


FIG. 3 THE EFFECT OF A SINGLE HOLE PLACED IN THE CENTER OF THE TEST SPECIMEN ON ITS ULTIMATE TENSILE STRENGTH

able ultimate failure stress. Practical application of the theories that follow would dictate the use of the minimum guaranteed properties for the materials concerned rather than probable failure stresses.

Ultimate Tensile Strength—Perforated 24ST-3 Aluminum-Alloy Sheet

For the case of uniform tension, the mathematical theory of elasticity indicates that a single hole placed in the center of a plate of isotropic material of infinite width produces a stress concentration at the edge of the hole of three times the value that would be produced if no hole were present. Various experimental methods, such as photoelasticity and the brittle material method, have shown that such a concentration does exist and that the magnitude is of the order previously stated.[9]

The chief interest herein is, of course, beyond the point where actual yielding of the material occurs. For years it has been assumed, and rightly so, that the stress concentration does not control the ultimate failure of such ductile materials as structural steel. Holleman[10] has verified this by tests on annealed X4130 steel. His experiments show that no reduction of strength occurs when the tensile stress produced is calculated on the basis of net area. In other words, regardless of the size of the hole or of the number of holes placed in a single transverse row, there is no reduction in the ultimate net area stress. Consideration of the conventional stress-strain diagram for this material leads one to realize that these results were to be expected. Beyond the yield point, this material yields, for all practical purposes, without any increase in stress. Therefore, even though yielding at the hole edge occurs early in test, no stress concentration remains when ultimate failure occurs.

Study of the stress-strain diagram for the less ductile 24ST-3 aluminum alloy reveals that different conclusions must be drawn for materials of its type. Certainly the point at which it yields is not well defined; and, of more importance, the stress required beyond yield, for any definite strain, increases until ultimate failure occurs. This means that some stress concentration exists even at the instant of ultimate failure and that this material's efficiency (based on net area) will be less than 100 per cent. Results by Holleman,[10] Stevenson,[11] and by this author (see Fig. 3) verify the conclusions drawn for the case of a single hole placed in the center of the test specimen.

As can be seen in Fig. 3, the per cent of original strength based on net area decreases rapidly with an increase in hole size until approximately 18 per cent of the cross-section area has been removed. Here a steady increase in the per cent of original strength based on net area becomes apparent as the area removed increases. If one keeps the actual stress-strain diagram in mind, a probable explanation of this phenomenon may be had from the theory of elasticity. The equation for the normal unit stress on a cross section, which includes a single hole in the center, in terms of the unit stress on a cross section sufficiently removed so that no effect of the hole is present, is

$$S_t = \frac{S_0}{2}\left(2 + \frac{r^2}{x^2} + 3\frac{r^4}{x^4}\right)^9$$

where

r = the radius of the hole
x = the distance to any point on the cross section measured from the center of the hole
S_0 = the unit stress on a cross section unaffected by the hole

It can thus be seen that the section near the hole yields long before other portions reach the yielding stage. Of course, once yielding has occurred, the equation is no longer valid, since the assumption of elastic behavior no longer holds. It is probable, however, that the portion below yield stress is stressed by a similar equation. We know that for the aluminum alloy continued yielding does not occur without additional stress. Thus, the procedure continues to failure with a stress concentration that becomes more intense as the point in question is moved from the edge of the sheet to the edge of the hole.

The portion of the curve (Fig. 3) which shows a definite decrease in efficiency has in all likelihood a slow process of failure. The stress concentration is on a limited portion of the cross section, and actual failure probably occurs here when the rest of the cross section is still capable of carrying the entire load. Therefore, the rupture slowly proceeds out from the hole until the remaining portion can no longer carry the entire load. This theory was apparently verified during actual testing, since an actual slow process of yielding did occur over a period of time, decreasing in length as the portion of the cross section removed by the hole increased.

That the curve shows an increase in efficiency after more than 18 per cent of the cross section has been removed is as was expected. The remaining portion of the cross section, as the area removed is increased, falls to an increasing degree within the highly stressed portion. Therefore, the strain is more nearly uniform at time of failure, which results in a higher efficiency based on net area.

TABLE 1

Effect of a Second Hole Not in the Same Transverse Axis of the First

24ST-3 Aluminum-Alloy Sheet, 0.032 Nominal Thickness

No.	Hole Diameter	Specimen Description	Net Area Stress in Lbs. per Sq.In.	Reduction in Efficiency
1	0.0595	Single hole in center	60,700	...
2	0.0595	Second hole added, 0.12 in. above first in center of specimen	58,600	3.4
3	0.0595	Same as (2)	58,600	3.4
4	0.0595	Two holes centered on 45° diagonal, 0.20 in. apart	56,400	7.2
5	0.0595	Same as (4)	55,700	8.2
6	0.1200	Single hole in center	54,200	...
7	0.1200	Single hole 0.24 in. above first in center of specimen	49,100	9.5
8	0.1200	Same as (7)	49,700	9
9	0.1200	Two holes centered on 45° diagonal, 0.20 in. apart	44,000	19
10	0.1200	Same as (9)	43,200	20.3

Results by Holleman[10] and Stevenson[11] indicate that, whenever a second hole is placed in the specimen, a reduction in efficiency occurs, whether the hole is placed in the same transverse row or elsewhere. This was verified (see Table 1) with one encouraging exception. Their reports were based on test results in which the size of the holes placed in the specimen were relatively large. They were considering, in general, holes for attachments by rivets and bolts. Fig. 4 presents results from specimens that had four 0.018-in. diameter holes in a transverse row, spaced 0.100 in. apart. Rows were spaced 0.100 in. apart and were varied in number from one to five. As can be seen from this figure, the addition of entire rows had no effect on the net efficiency of the specimens. Fig. 5 presents similar results for a case in which four 0.031-in. diameter holes were spaced 0.100 in. apart in transverse rows. We can therefore say conservatively that the addition of extra rows of holes can be made with no decrease in efficiency provided the hole diameter is no greater than 0.031 in. and if the holes are spaced at least 0.100 in. apart. Successful flight tests, in which the laminar boundary layer was stabilized by suction through holes 0.018 in. and less in diameter and spaced 0.100 in. apart, have been conducted at Mississippi State College.[5] For practical purposes, then, it would seem that knowledge of the fact that holes of 0.031 in. in diameter can be used without a decrease in efficiency is all that is needed. Even more desirable, however, is an understanding of the phenomenon that controls the spacing and, therefore, the limitations upon it.

Unsuccessful attempts were made by the author to find a theoretical method of predicting ultimate failure in tension for perforated sheet, but a reliable empirical method based on the test results from specimens with only a single hole in the center of the test section was found.

Articles published by Childs and Kelly[12] concerning studies of the effect of abrupt changes of the cross section on the unit stress of rubber models proved interesting. Although the stress-strain diagram for rubber deviates appreciably from a straight line, even at low stress, at least some idea of strain distribution emerges from their research. A single hole placed in the center of a rubber model results in a strain distribution that can be closely approximated by a straight line—that is, of course, a maximum at the hole and a minimum at the edge of the sheet. If, on the same transverse axis, an additional hole is placed in the model, and, if we assume that the strain distribution for a single hole can be expressed by a straight-line relation, the strain distribution—by the principle of superposition—becomes constant over the portion of the cross section between the two holes and a failure carries a stress equal to the ultimate tensile stress of the material.

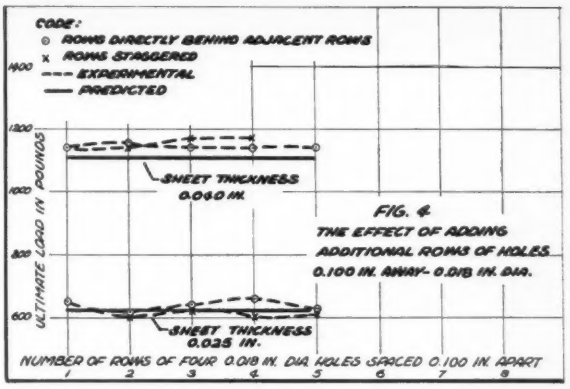


FIG. 4. THE EFFECT OF ADDING ADDITIONAL ROWS OF HOLES 0.100 IN. AWAY- 0.018 IN. DIA.

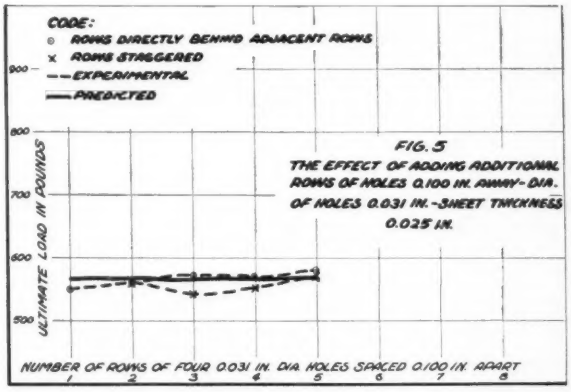


FIG. 5 THE EFFECT OF ADDING ADDITIONAL ROWS OF HOLES 0.100 IN. AWAY- DIA. OF HOLES 0.031 IN.-SHEET THICKNESS 0.025 IN.

By means of photoelasticity, Coker[13] has studied the stress concentrations on tension specimens in the elastic range which result from symmetrical fillets formed by semicircles at the plate edge. Where these fillets remove 25 per cent of the cross section, the stress concentration amounts to only 1.37 of the average stress, and the area over which the stress concentration exists is a relatively small portion of the total cross section. As the percentage of the area removed by the fillets decreases, both the area affected by the concentration and the degree of concentration become smaller. Hence, the conclusion may again be drawn that, for all practical purposes when the holes are of the type desired for boundary-layer control by suction, the stress

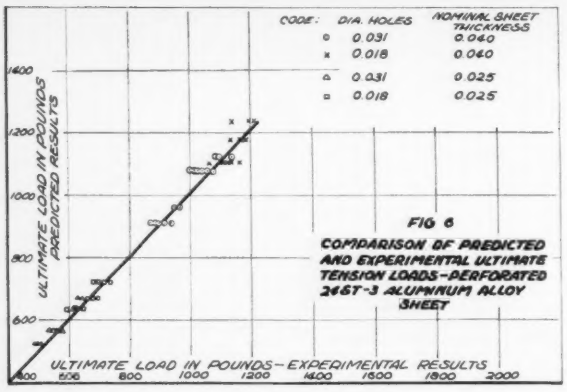

CODE: DIA. HOLES NOMINAL SHEET THICKNESS
o 0.031 0.040
x 0.018 0.040
Δ 0.031 0.025
□ 0.018 0.025
ULTIMATE LOAD IN POUNDS PREDICTED RESULTS
ULTIMATE LOAD IN POUNDS—EXPERIMENTAL RESULTS

FIG 6
COMPARISON OF PREDICTED AND EXPERIMENTAL ULTIMATE TENSION LOADS—PERFORATED 24ST-3 ALUMINUM ALLOY SHEET

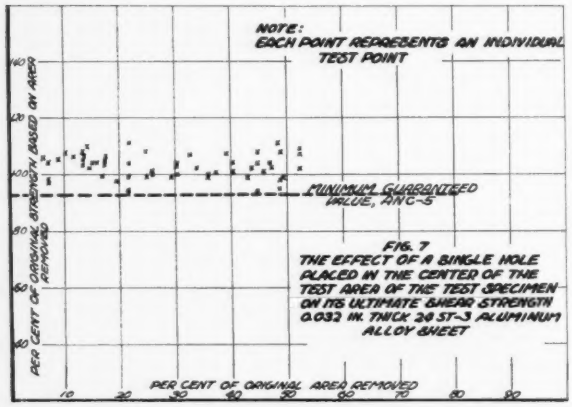

NOTE:
EACH POINT REPRESENTS AN INDIVIDUAL TEST POINT
MINIMUM GUARANTEED VALUE, ANC-5
PER CENT OF ORIGINAL STRENGTH, BASED ON AREA REMOVED
PER CENT OF ORIGINAL AREA REMOVED

FIG. 7
THE EFFECT OF A SINGLE HOLE PLACED IN THE CENTER OF THE TEST AREA OF THE TEST SPECIMEN ON ITS ULTIMATE SHEAR STRENGTH 0.032 IN. THICK 24 ST-3 ALUMINUM ALLOY SHEET

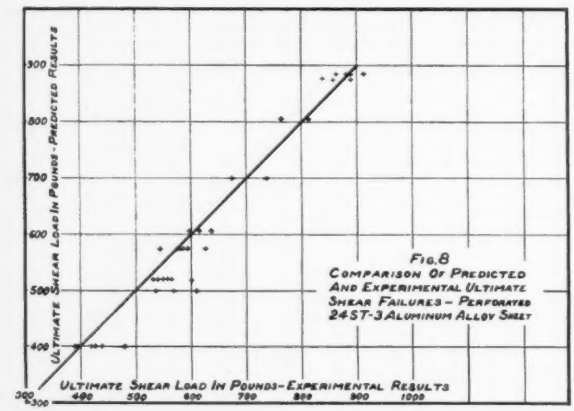


FIG. 8
COMPARISON OF PREDICTED AND EXPERIMENTAL ULTIMATE SHEAR FAILURES—PERFORATED 24ST-3 ALUMINUM ALLOY SHEET

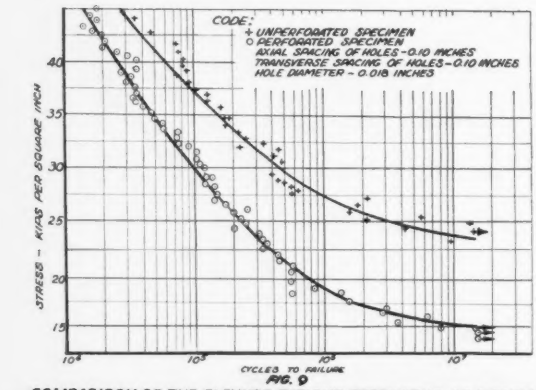


FIG. 9
COMPARISON OF THE FLEXURE FATIGUE STRENGTHS OF PERFORATED AND UNPERFORATED 24ST-3 ALUMINUM ALLOY SHEET—NOMINAL SHEET THICKNESS 0.040 INCHES

is constant over the cross section between the holes. Although it may seem that the use of such reasoning would lead to slightly unconservative results, such is not the case as will be shown later.

If the above theory can be applied, there remains to be considered only the portion of the cross section which lies between the last hole in the row and the edge of the sheet. This information can be secured directly from tests in which only one hole was placed in the center of the sheet.

A combination of the theory of constant strain between two holes in a single transverse row and the experimental results from the effect of a single hole has been used to predict the ultimate failure of 94 test specimens. A comparison between the predicted ultimate failure loads and the experimental failure loads is shown in Fig. 6. Specimens containing holes of diameters of 0.031 in. and of 0.018 in. were used. The number of rows was also varied from one to five. In some cases the holes were placed directly behind each other in the transverse rows, and in others they were staggered in such a way that the offset was exactly half of the transverse spacing. Sheet thicknesses of 0.025 in. and 0.040 in. were used for all cases.

As illustrated, variations between the predicted and experimental loads are relatively small. A variation of as much as 5 per cent was the exception, and in only a few cases did one occur.

Ultimate Shear Strength—Perforated 24ST-3 Aluminum-Alloy Sheet

Fig. 7 presents the results of singe-hole shear studies on 0.032-in. 24ST-3 aluminum-alloy sheet. In these studies the effect of a single hole drilled in the center of the test area was determined. The hole diameters were changed so that the portion of the failure cross-section area removed varied from zero to about 50 per cent of the original cross section. Throughout this range, the remaining material proved capable of carrying the ultimate shear load of the unperforated material. Each of the 72 specimens developed an average ultimate shear stress above the minimum guaranteed ultimate shear stress of the unperforated material.[14]

Assuming all remaining material capable of developing the full ultimate shear strength of the unperforated material, the ultimate failure loads of the 36 perforated specimens were predicted. A comparison of these predicted failure loads and the corresponding experimental failure loads is shown in Fig. 8. The close agreement between these shows that this method of predicting the ultimate shear failure is reliable for this perforated material.

This method of predicting ultimate shear failure for perforated materials was checked by testing perforated 24ST-3 aluminum-alloy tubes in pure torsion. As was the case for the sheet materials, the predicted ultimate failure and the experimental failure were in close agreement.

Flexure Fatigue of Perforated 24ST-3 Aluminum-Alloy Sheet

The results of an investigation to determine the effect of perforations on the flexure strength of 24ST-3 aluminum-alloy sheet are shown in Fig. 9. The perforated specimens were prepared by drilling transverse rows of holes 0.018 in. in diameter with spacing equal to 0.10 in. The spacing between the rows was also 0.10 in. Material of nominal thickness, 0.040 in., was used throughout the investigation, and the loading was always applied parallel to the direction of rolling of the sheet.

The applied stress values shown for the extreme fibers of the perforated specimens are the average stress that they carried for any given loading. Below the elastic limit of the aluminum alloy, there certainly exists a large variation in the stress pattern between the holes, but no attempt was made to determine these localized values since they have no effect on the final conclusions to be drawn from the investigation.

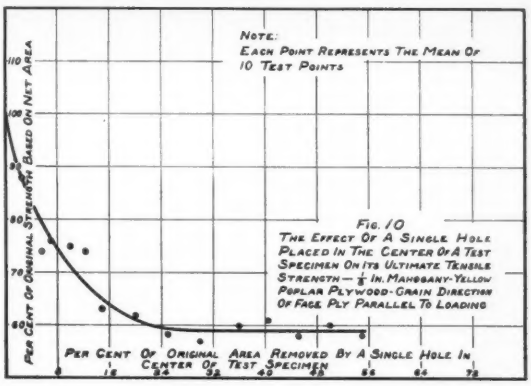
The rate of flexure was 1,800 cycles of completely reversed stress per min. The loading continued uninterrupted until complete failure occurred.

As was to be expected, Fig. 9 shows considerable reduction in life expectancy for the perforated specimens. This reduction, however, is somewhat smaller than would be expected if only the stress concentration factors normally produced at circular holes were considered.

Often the figure of 2,000,000 completely reversed cycles of stress is used in comparing the flexure-fatigue-carrying abilities of various types of materials. If this life expectancy is considered, the investigation shows that the unperforated materials can be stressed to approximately 26,000 lbs. per sq.in. while the perforated materials can be stressed to only about 17,000 lbs. per sq.in. These figures represent a loss in load-carrying ability of about one-third. If the life demanded of a specimen is greater than 2,000,000 completely reversed cycles, the reduction in load-carrying ability will be greater than one-third as compared to the load-carrying ability of the unperforated specimens; but, if the life demanded is less than 2,000,000 cycles, the reduction in load-carrying ability will be less than one-third.

Analysis Procedures—Plywoods

The method of least squares for observations of equal weight was applied to all experimental data received from tests involving plywood materials, but only the arithmetical mean and the probable error of a single observation were determined.[15] All data from plywood tests which are later presented in this report will thus be given in the form of $M \pm r$: M is the arithmetical mean, and r is the probable error of a single observation. Whenever the data were involved in computing such percentages as per cent of original strength based on net area, only the arithmetical mean was considered.


NOTE:
EACH POINT REPRESENTS THE MEAN OF 10 TEST POINTS
PER CENT OF ORIGINAL STRENGTH BASED ON NET AREA
110
100
90
80
70
60
FIG. 10
THE EFFECT OF A SINGLE HOLE PLACED IN THE CENTER OF A TEST SPECIMEN ON ITS ULTIMATE TENSILE STRENGTH — 1/8 IN. MAHOGANY-YELLOW POPLAR PLYWOOD-GRAIN DIRECTION OF FACE PLY PARALLEL TO LOADING
PER CENT OF ORIGINAL AREA REMOVED BY A SINGLE HOLE IN CENTER OF TEST SPECIMEN
0
16
24
32
40
48
56
64
72

Stress Concentration—Woods and Plywoods

The intensity of the stress concentrations produced by a hole placed in the center of a sheet of wood that is under tension is dependent upon many variables. Large variations in Young's modulus, the shear modulus, and Poisson's ratio result in large differences in the value of the concentration factors produced in any given wood material as the direction of the applied tensile load is varied in relation to the grain direction. Since the relationships that exist between the moduli and Poisson's ratio vary from specie to specie (see Table 2–9, reference 16), a pattern determined for any given wood would likely be quite different from what would exist in another specie under similar conditions. Just as the intensity of the concentration at the hole varies so does its effect on the material at any given distance from the hole.

Since the grain of the individual plies of plywood varies as to direction (generally aircraft plywoods have the grain of adjacent plies at right angles to each other), a more uniform strength and elastic property condition exists. As the tensile load is applied at different angles to the face grain direction, however, a considerable variation in the stress concentration factor still occurs. (The application of equations 2.14 and 2.15 of reference 16 to any plywood material will readily verify this statement.) Also, differences in the stress concentration pattern around a hole will be found for similar plywoods constructed from different species of wood. For these reasons the results to be presented later must be considered to apply only to the plywoods in question and to these plywoods under the specified conditions.

The performance of other plywoods under similar conditions surely can be expected to be similar in nature, and general conclusions can be drawn concerning them; but direct use of the data contained herein is not possible.

Ultimate Tensile Strength—Perforated Plywoods—Face Grain Direction Parallel to the Loading Direction

The results of single-hole studies on $^1/_8$-in. mahogany-yellow poplar plywood are shown in Fig. 10. A single hole was drilled in the center of the test specimen, and its effect upon the ultimate tensile strength of the spec-

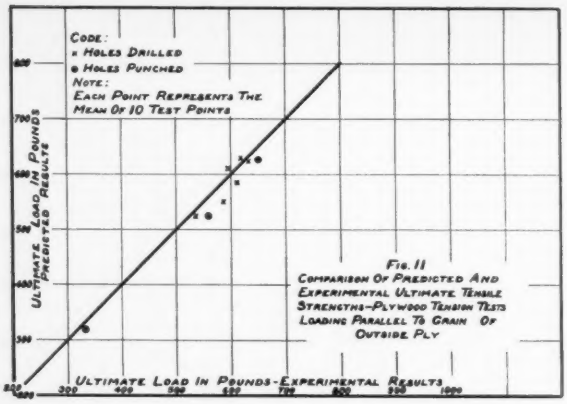

CODE:
x HOLES DRILLED
● HOLES PUNCHED
NOTE:
EACH POINT REPRESENTS THE MEAN OF 10 TEST POINTS
ULTIMATE LOAD IN POUNDS PREDICTED RESULTS
ULTIMATE LOAD IN POUNDS-EXPERIMENTAL RESULTS

FIG. 11
COMPARISON OF PREDICTED AND EXPERIMENTAL ULTIMATE TENSILE STRENGTHS—PLYWOOD TENSION TESTS LOADING PARALLEL TO GRAIN OF OUTSIDE PLY

imen was determined. The loading in every case was parallel to the face grain direction.

It is obvious from this plot that the stress concentration produced by the hole controls to a large degree the ability of the material to resist the ultimate tensile load. The conventional stress-strain diagrams for the two woods involved are a key to this action. The steepness of their stress-strain curves, even after the proportional limit has been exceeded, means that a large stress concentration must still exist at the time of ultimate failure. That is, even though the large stress concentration factor produces local yielding at the hole early in the test, this yielding does not continue without a continued increase in the local stress. Therefore, at the time of first local failure and instantly thereafter when total failure occurs, an uneven stress distribution exists, and thus a reduction in efficiency based on net area occurs.

As the percentage of the area removed by a single hole increases from zero, a rapid reduction in efficiency based on net area occurs. This rapid reduction continues until about 25 per cent of the cross-section area has been removed, and then the effectiveness of the remaining material is about 60 per cent. When from 25 to above 50 per cent of the cross-section area has been removed, the efficiency of the remaining material for all practical purposes is constant at 60 per cent. No tests were conducted where more than 55 per cent of the cross section was removed by a single hole.

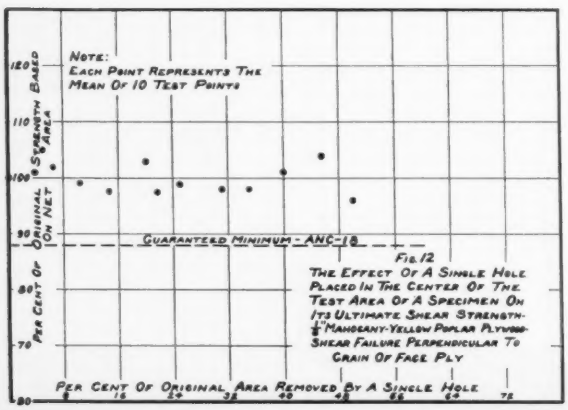

NOTE:
EACH POINT REPRESENTS THE MEAN OF 10 TEST POINTS
PER CENT OF ORIGINAL NET STRENGTH BASED ON NET AREA
GUARANTEED MINIMUM - ANC-18
PER CENT OF ORIGINAL AREA REMOVED BY A SINGLE HOLE

FIG. 12
THE EFFECT OF A SINGLE HOLE PLACED IN THE CENTER OF THE TEST AREA OF A SPECIMEN ON ITS ULTIMATE SHEAR STRENGTH-1/8" MAHOGANY-YELLOW POPLAR PLYWOOD-SHEAR FAILURE PERPENDICULAR TO GRAIN OF FACE PLY

A greater reduction in efficiency occurs in the plywood than in the aluminum alloy. Also, in the range from 0–25 per cent cross-section area removed by a single hole, the rate of reduction is much higher for the plywood. This reduction in efficiency and its rate can at least be partially explained by two factors. First, the stress concentration factors produced in the core of the plywood material while it is still stressed in the elastic range is much larger than that produced in the aluminum alloy. If no relief is considered to be received from the face plies, this factor as calculated from equation 2.14 of reference 16 is 5.48 as compared with 3.0 for the aluminum alloy. The face material itself, considering no increase from the core, has a factor of 2.35. In any event, the overall concentration considerably exceeds that produced in the aluminum alloy. Second, the extreme steepness of the tensile stress-strain curve beyond the elastic limit continues much of this concentration until ultimate failure occurs.

That the curve fails to continue its downward trend beyond the point where 25 per cent of the cross-section area was removed was to be expected. As the area removed increases, the remaining portion falls to an increasing degree within the high stressed portion and, therefore, is more nearly equally stressed at the time of failure. If the tests had been continued beyond 55 per cent cross-section area removed, very likely an increasing efficiency based on net area would have been found. Possibly no earlier increase was found because of the fact that the material some distance from the hole was little affected by the stress concentration produced by the hole.

If at the time of ultimate failure the theory of constant strain between two properly spaced holes holds for perforated plywoods, only the results of Fig. 10 are necessary for predicting the ultimate failure load in tension for this material. On the assumption that all material between two adjacent holes is capable of carrying the ultimate tensile stress of the unperforated material and that the portion between the last hole in the row and the edge of the sheet is capable of carrying only that percentage found in the single hole studies (see Fig. 10), the ultimate failure loads have been predicted for 90 test specimens. Fig. 11 gives a comparison of the predicted and experimental failure loads for these specimens, and, as shown, good agreement exists. Fig. 11 also shows predicted and ultimate failure loads for perforated 0.070 mahogany-mahogany plywood. Good agreement also exists for this material.

Ultimate Shear Strength—Perforated 1/8-In. Mahogany-Yellow Poplar Plywood—Loading Direction Parallel or Perpendicular to the Face Grain

The results of single-hole shear studies on 1/8-in. mahogany-yellow poplar plywood are shown in Fig. 12. The effect of various size holes drilled in the center of the test area on the specimens' ultimate shear strengths was determined. For these studies the face grain was always perpendicular to the direction of loading and, therefore, failure was always across the face grain.

TABLE 2
Ultimate Shear Strength Perforated 1/8-In. Mahogany-Yellow Poplar Plywood

Test No.†	Drill Diameter*	Transverse Spacing*	Longitudinal Spacing*	No. of Rows	No. of Holes in Row	Experimental Ultimate Failure	Per Cent Original Strength‡	Predicted Ultimate Stress
			(Loading Perpendicular to Grain)**					
1	0.018	0.1	0.1	3	2	198	104	190
2	0.025	0.1	0.1	3	2	177	96.5	185
3	0.031	0.1	0.1	3	2	176	98.5	179
4	0.018	0.1	0.1	3	3	187	102	183
5	0.025	0.1	0.1	3	3	171	98	174
6	0.031	0.1	0.1	3	3	161	96.5	167
			(Loading Parallel to Grain)++					
7	0.018	0.1	0.1	3	2	203	104.5	194
8	0.025	0.1	0.1	3	2	183	97.5	188
9	0.031	0.1	0.1	3	2	192	105	183
10	0.025	0.1	0.1	3	3	190	101.5	187
11	0.025	0.1	0.1	3	3	189	107	177
12	0.031	0.1	0.1	3	3	173	101.5	170

* All dimensions in inches.
† Each test represents mean of 10 test values.
‡ Per cent original strength based on net area.
** Probable ultimate strength failure—1,640 lbs. per sq.in. (based on 10 tests).
++ Probable ultimate strength failure—1,670 lbs. per sq.in. (based on 10 tests).

As shown in Fig. 12, the per cent area removed by a single hole was varied from 0–50 per cent. For all practical purposes the load-carrying ability of the remaining material did not diminish or increase, regardless of the size of the hole drilled in the test area. In all instances, the experimental average net area stress exceeded the guaranteed minimum strength for this material as published in reference 16.

With the preceding results on this material and the results from the aluminum shear tests as a guide, it was assumed that the ultimate shear strength of this material, when perforated, could be predicted by considering the remaining material fully capable of carrying the ultimate shear stress of the unperforated material. A comparison of predicted and experimental ultimate failure loads for six variations of perforated 1/8-in. mahogany-yellow poplar plywood with the face grain perpendicular to the loading direction is shown in the first half of Table 2. Close agreement between theory and experiment is shown; and, as a result of this, the ultimate failure loads for similar specimens whose face grain was parallel to the loading direction were predicted. The second half of Table 2 gives a comparison of these predicted values with the experimental failure loads and shows that the method of predicting failure is reliable in this case as well as when the loading was perpendicular to the face grain.

CONCLUSIONS

(1) From a consideration of both the aerodynamic and structural aspects, indications are that any early application of boundary-layer control by suction can most advantageously be applied through use of perforated lifting surfaces of conventional design. All other methods previously advocated result in less efficiency from either the aerodynamic or structural point of view or from both.

(2) The theories presented in this report for predicting the ultimate tensile and shear strengths of perforated 24ST-3 aluminum-alloy sheet can be used for design purposes. Although the accuracy compares well with the accuracy of other stress analysis procedures, the use of a factor of 0.95 of the predicted value would guarantee conservative analysis. The decrease in the strength-weight ratio of the perforated aluminum alloy as compared to the unperforated alloy should by no means offset the aerodynamic improvements received from boundary-layer control by suction.

(3) The theories presented for the prediction of the ultimate tensile and shear strengths of perforated plywood are suitable for design purposes. The per cent reduction in strength-weight ratio is slightly higher for the plywoods than for the aluminum alloy because of the larger effect of the perforations on the ultimate tensile strength of the plywoods. This can be explained by the types of stress-strain curves possessed by the materials concerned. Beyond the yield point, the slopes of the stress-strain curves decrease very little, and therefore the degree of the stress concentration produced at the hole when the material is stressed below the yield point decreases very little as the material is stressed to ultimate tensile failure.

(4) The fact that additional holes of the type needed for boundary-layer control by suction can be added without a reduction of efficiency, as far as the tensile strengths of the materials studied are concerned, is of primary importance. Without further investigation, the addition must be limited to holes of no greater diameter than 0.031 in. and minimum spacing equal to 0.10 in.

(5) The effects of fatigue will in all probability be the most serious structural requirements imposed on the perforated materials. Although considerable reduction in life expectancy does occur under the action of flexure fatigue, this loss is much less than would be expected if only the stress concentration factors normally produced at a circular hole are considered. If the figure of 2,000,000 completely reversed cycles of stress is demanded, the loss in load-carrying ability for the perforated material is about one-third. If the life demanded is

greater than 2,000,000 cycles, the reduction in load-carrying ability will be greater than one-third; but, if the life demanded is less than 2,000,000 cycles, the reduction in load-carrying ability will be smaller than one-third.

(6) The theories previously discussed must be applied only to the aluminum-alloy and the plywood materials studied. Generalities concerning the characteristics of other aluminum alloys and other plywoods can be drawn, but direct application of the data presented is not possible.

References

[1] Stokes, Sir George Gabriel, *On the Theories of the Internal Friction of a Fluid in Motion*, Cambridge Transactions, Vol. 8, 1845.

[2] Prandtl, L., *Ueber Flussigkeitsbewegung bei sher kleiner Reibung*, Verhandlung III, Intern. Math. Kongress, Heidelberg, 1904, reprinted in Vier Abhdnlg. zur Hydrodynamik, Göttingen, 1927.

[3] Pfenninger, W., *Experiments on a Laminar Suction Airfoil of 17 Per Cent Thickness*, Journal of the Aeronautical Sciences, Vol. 16, No. 4, p. 227, April, 1949.

[4] Goldstein, Sydney, *Low-Drag and Suction Airfoils*, Journal of the Aeronautical Sciences, Vol. 15, No. 4, p. 189, April, 1948.

[5] Raspet, August, *Mechanism of Automatic Trailing Edge Suction*, Research Report No. 1, The Engineering Research Station, Mississippi State College, 1951.

[6] Preston, H. H., and Roweliffe, B. A., *Note on Sintered Metal with a View to Its Use as a Porous Surface in Distributed Suction Experiments*, Aeronautical Research Council, Technical Report 9383.

[7] *Paint, Naval Stores, Wood Adhesives, Paper, Shipping Containers*, American Society for Testing Materials, Standards, Part 4, 1949.

[8] *Non-Ferrous Metals*, American Society for Testing Materials, Standards, Part 2, 1949.

[9] Seely, Fred B., *Advanced Mechanics of Materials;* John Wiley & Sons, Inc., New York, 1948.

[10] Holleman, Clarence H., *Tension Joints in Aircraft Structures*, Journal of the Aeronautical Sciences, Vol. 10, No. 8, p. 295, October, 1943.

[11] Stevenson, C. H., *The Effects of Open Holes on the Tensile Strength of Some Aluminum Alloys*, Journal of the Aeronautical Sciences, Vol. 13, No. 8, p. 395, August, 1946.

[12] Childs and Kelly, *The Resistance of Materials, the Effect of Sudden or Abrupt Changes in the Section on the Distribution of the Uni-Stress*, Railway Mechanical Engineer, March, April, and May, 1919.

[13] Coker, E. G., *Engineering Problems of Stress Distribution*, Proceedings, First International Congress for Applied Mechanics at Delft, 1924.

[14] *Strength of Metal Aircraft Elements*, Munitions Board, Aircraft Committee, ANC-5, June, 1951.

[15] Bartlett, Dana P., *The Method of Least Squares*, Harvard Cooperative Society, Cambridge, Mass., 1933.

[16] *Design of Wood Aircraft Structures*, Munitions Board, Aircraft Committee, ANC-18, June, 1951.

Strategic Air Command (Concluded from page 23)

II planes, to miss the target. That bomber with its crew and weapons over enemy territory represents an investment that cannot be measured in dollars but only in national resources. Yet, when the 50 cent tube blows, our investment goes down the drain. It is the old story of the loss of a kingdom for want of a dependable nail.

Personally, I do not think the best of anything has been developed yet. But, I know, and I am sure the crews of SAC know, when it is, American engineers will probably build it.

The American aviation industry has given us the most highly developed equipment in the world with which to do our job. And we, in turn, have developed crews and tactics to operate that equipment with maximum effectiveness. We in SAC will certainly continue to do our part by training continuously in order that we may exploit the equipment you give us to its fullest capability.

In outlining the present operational capabilities of the Strategic Air Command, I hope I have shown you that SAC is prepared today, within its present resources and with the tools that you have provided us, to immediately mount America's "Sunday punch" if a major war should come, say, next Sunday. I would add a final thought as to the purpose of all our efforts.

At the time of Pearl Harbor, there were in the United States approximately 600 military airplanes of all types suitable for combat. The first United States bomber attack from the United Kingdom was several months later, in August of 1942. Although newspapers headlined the fact that the U.S. Air Force had gone into action, the fact was, as I mentioned earlier, the Air Force had not as yet been built.

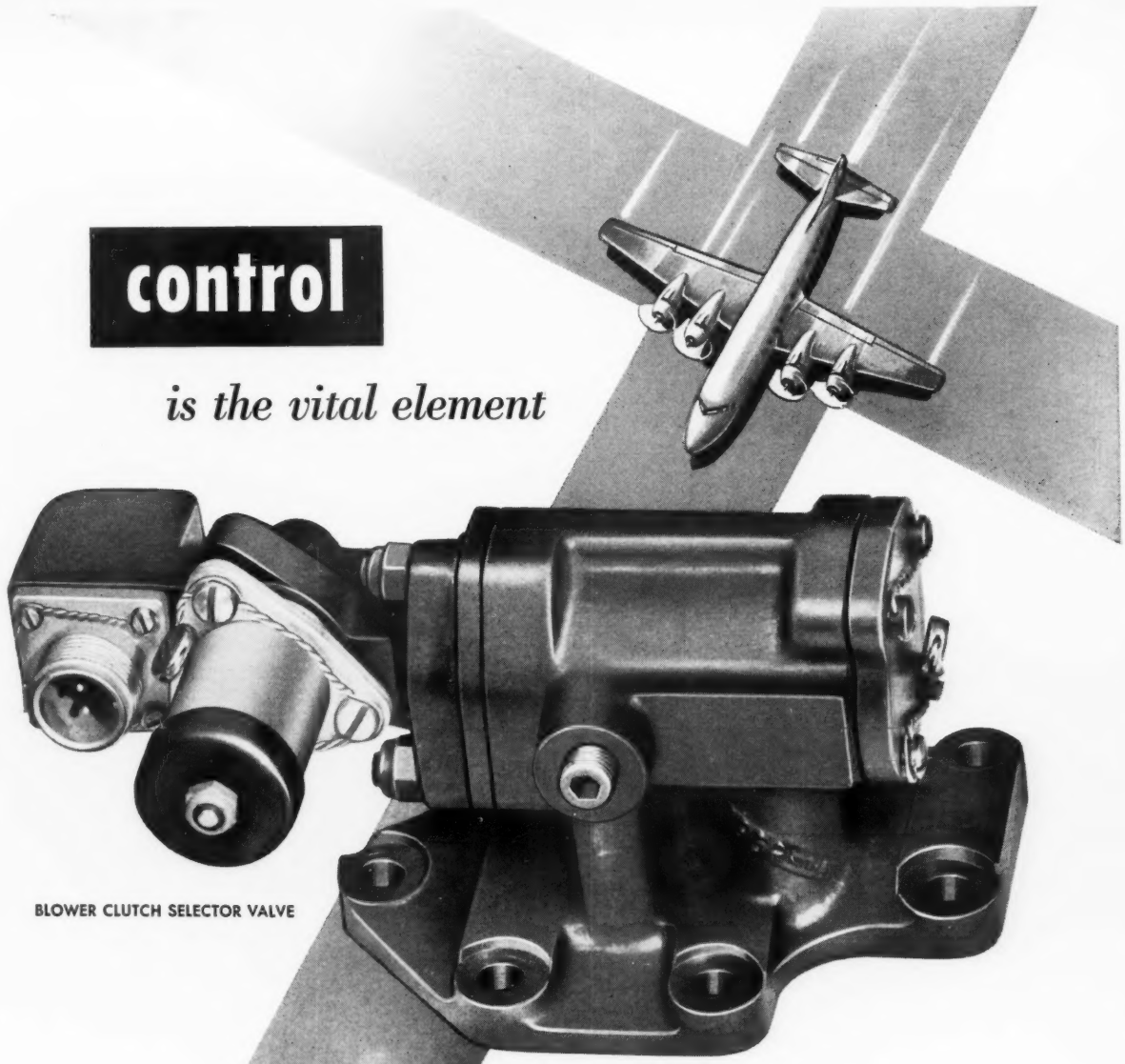
In any major "all-out" war, we would not have this period for the unmolested building of an atomic striking force. There is certainly a real possibility that effective production may be curtailed and that we may have to carry out the atomic counter offensive with what we have on hand D-Day.

The long-range bomber and the atomic bomb with its terrible destructive capacity turns the factor of time again against the defender. Every important target in even the world's largest nation can be reached at the most within 2 hours after bombers cross its frontier. Time is of utmost value. There may not be enough of it once an atomic attack is launched—hence, the reason for the existence and the constant poised readiness of the Strategic Air Command.

There is one other significance in this brief sketch of SAC which I am sure has not escaped you. I would remind you that there are two ways to determine military requirements: one is to calculate what force is required to do a given job under a given set of conditions, and another is to determine what force, in what composition, and what disposition will *convince* an aggressor that he cannot gain by starting a universal war. In these times of tension, I am sure you share with me the hope and the belief that our nation's air power will continue to be convincingly superior.

control

is the vital element



BLOWER CLUTCH SELECTOR VALVE

ADEL *quality* and *performance* is consistently maintained—where it counts most—in the air.

ADEL Aircraft Equipment has answered the challenge of the exacting requirements for modern aircraft and *surpasses* all specifications right across the board.

Aircraft manufacturers who *specify* ADEL Hydraulic and Pneumatic Control Equipment, Heater, Anti-Icing and Fuel System Equipment and Engine Accessories, *prove* the fact that ADEL's reputation as designer and manufacturer of Aircraft Equipment is well deserved.

ADEL . . . *adding safety from take-off to landings*

A DIVISION OF GENERAL METALS CORPORATION

BURBANK, CALIFORNIA • HUNTINGTON, WEST VIRGINIA

CANADA: RAILWAY & POWER ENGINEERING CORPORATION, LIMITED

ADEL

News of Members

(*Continued from page 19*)

Robert J. Harris (TM), Structures Engineer, Grumman Aircraft Engineering Corporation. Formerly, Aeronautical Engineer, Aircraft Vulnerability Section, Weapons Effectiveness Branch, Terminal Ballistics Laboratory, Ballistics Research Laboratories, Aberdeen Proving Ground, Md.

Stanley C. Hellman (TM), Assistant Director of Contract Administration, North American Aviation, Inc. Formerly, Assistant General Manager, Columbus Division, North American Aviation.

John R. Howard (M), Chief of Field Service, Corporal Division, Firestone Tire & Rubber Company. Formerly, Project Engineer, Guided Missile Engineering Test, Engineering and Development Division, Ordnance Corps, White Sands Proving Ground, N.M.

Dr. Nelson H. Kemp (TM), Research Department, United Aircraft Corporation. Formerly, Candidate for Doctoral Degree and Research Assistant, Graduate School of Aeronautical Engineering, Cornell University.

W. A. Klikoff (AF), Deputy Chief, Aircraft Engineering Division, W-235, Civil Aeronautics Administration, Department of Commerce, Washington, D.C. Formerly, Chief, Aviation Safety Division, CAA, Los Angeles.

Michael Maletz (M), Design Specialist, Research and Development Laboratory, Aviation Division, Rheem Manufacturing Company. Formerly, Structural Engineer, Lockheed Aircraft Corporation.

Luc A. Martin, now Private, Battery C, 34th Field Artillery Battalion, Fort Dix, N.J.

Betty J. McCoy (AM), Test and Data Engineer, Link Aviation, Inc. Formerly, Service Engineer, Chase Aircraft Company, Inc.

Julius Merchant (M), Assistant Chief of Structures, Republic Aviation Corporation. Formerly, Project Structures Engineer, Republic.

Marvin L. Nelson (M), Head, Quality Control Division, Des Moines Plants, Solar Aircraft Company. Formerly, Manager, Engineering Division, Des Moines Plants, Solar.

Lieutenant General Donald L. Putt (F), Commander, Air Research and Development Command, USAF. Formerly, Vice Commander, Air Research and Development Command.

Joseph E. Russo (TM), Aeronautical Engineer, GS-9, Power Plant Branch, Overhaul and Repair Department, U.S. Naval Air Station, Norfolk, Va. Formerly, Mechanical Engineer, GS-9, Norfolk Naval Shipyard, Portsmouth, Va.

William R. Smanko (TM), Application Engineering Department, Westinghouse Electric Corporation. Formerly, Lieutenant, USAF, Project Engineer, Aircraft Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio.

Phillip E. Theobald (M), Project Engineer, Missile Branch, Chrysler Engineering Division, Chrysler Corporation. Formerly, Research Engineer, Supervisor, General Engineering Section, Willow Run Research Center, University of Michigan.

John C. Truman (M), Assistant Professor of Aeronautical Engineering, USAF Institute of Technology, Wright-Patterson AFB, Ohio. Formerly, Development Engineer, General Electric Company.

Omer Welling (AF), Chief, Aircraft Engineering Branch, CAA, Kansas City, Mo. Formerly, Deputy Chief, Aircraft Engineering Division, CAA, Washington, D.C.

G. D. Welty (AF), Manager of Aircraft Sales, Aluminum Company of America. Formerly, Manager of Forging Sales, Alcoa.

Maynard K. Wright (TM), Rocket Test Engineer, Bell Aircraft Corporation. Formerly, Private First Class, Project Engineer, Assistant, Redstone Arsenal, Ala.

Captain Paul J. Burr, USN, AFIAS, has been transferred to the Staff of the Commander, Air Force Pacific Fleet, San Diego NAS, where he is serving as Aircraft Availability Officer. He was formerly Head of the Air Branch, Office of Naval Research, Washington, D.C.

Corporate Member News

• **Aerojet-General Corporation, Subsidiary of The General Tire & Rubber Company . . .** The CAA has authorized the use of Aerojet-General's 14AS-1000 G-1 JATO unit as a source of stand-by power for commercial planes. This approval permits this unit to be carried on aircraft in the ready-to-fire position for 150 hours. Of this total, 100 are logged flight time and 50 hours are ground time. Except for being hermetically sealed and thus permitting operation at all altitudes, this new JATO unit is identical to previous models. Model 14AS-1000 G-1 produces 1,000 lbs. of thrust for 14 sec.

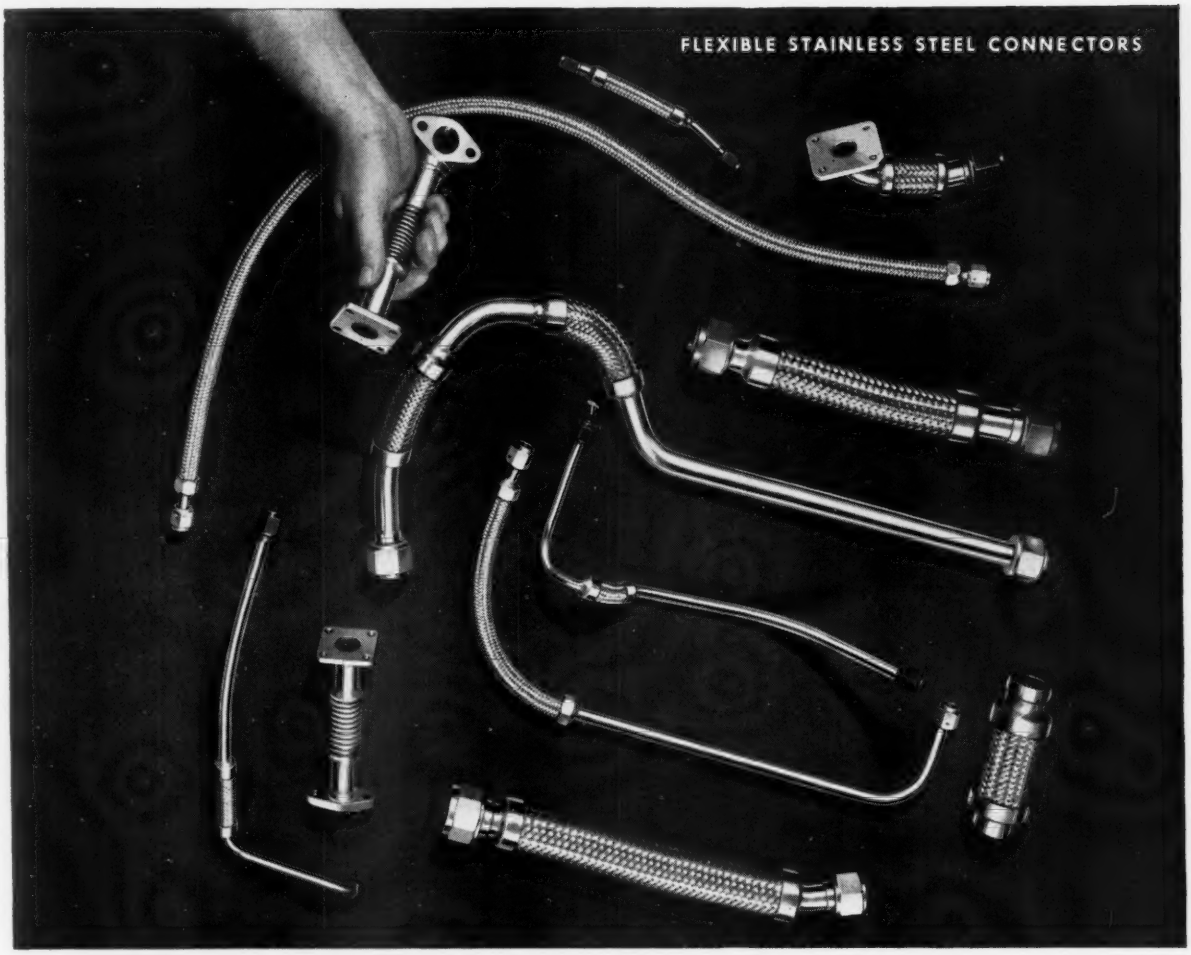
• **Aeroquip Corporation . . .** In order to fill the need for additional operating facilities and storage space to "handle its growing sales volume and product diversification," the Sterling Electric Motors, Inc., plant at Van Wert, Ohio, has been purchased by Aeroquip for an undisclosed amount. Aeroquip is transferring its Cheboygan, Mich., operations to the Van Wert plant, which is located some 100 miles south of the corporation's main plant in Jackson, Mich. It was said that with the addition of this plant at Van Wert, Aeroquip now has adequate manufacturing facilities for the production of its new products.

• **American Steel & Wire Division, United States Steel Corporation . . .** A major step in modernizing and expanding production facilities of the present Cuyahoga Works in Cleveland, Ohio, has been announced. This consists of the construction of a combination rod mill, billet storage areas, and rod storage areas which will have a rated capacity of 450,000 tons per year as compared with the present equipment that dates back to 1916 and has a rated capacity of 313,000 tons a year. The new mill will incorporate the latest facilities, equipment, and methods to effect maximum efficiency in production and to increase further the quality of the products. The new mill will be able to handle billets 3.25 in. square and 30 ft. long, weighing 1,050 lbs. each. Present billets weigh 600 lbs.

• **Bell Aircraft Corporation . . .** A 20,000-sq.ft. standardized steel building is now being erected at Bell's helicopter plant in Hurst, Tex., and should be ready about October 1. This building, like its twin put up at Hurst last May, will be employed as an assembly and flight-test plant for the corporation's new twin-rotor helicopters. The two buildings, both purchased from Luria Engineering Company, will be connected by a 60- by 112-ft. structure to be used for pilot offices and servicing.

• **Boeing Airplane Company . . .** The Fairchild AFB at Fairchild, Wash., has been selected as a supplementary base for the experimental and production flight-test program of the B-52 bombers. The selection of this base for the Boeing test site was approved in mid-June by the USAF Air Installations Board, Washington, D.C. The first production work on the B-52 is expected to begin about the middle of 1954.

• **The Bristol Aeroplane Company of Canada Limited . . .** J. Armand Limoges was recently named Secretary-Treasurer of The Bristol Aeroplane Company of Canada. Mr. Limoges is Vice-President and Secretary of Bristol Aeroplane Engines (Eastern) Limited.



Why leading jet engine makers call on American for complete flexible assemblies

There are a half-dozen good reasons why they do . . . and why it would be to your advantage to do the same.

When you call on American, you get the benefit of over 40 years of experience in engineering and manufacturing flexible metal hose and tubing.

You receive practical help—from capable engineers and designers—in the development of connectors that must move, flex or absorb vibration under the high temperature and pressure conditions—and weight limitations—found in jet service.

You can be certain your requirements and Government specifications will be met *exactly*. American has been meeting both for a good many years.

You can count on American Flexible Stainless Steel Assemblies—used to carry fuel, oil, hot and cold air, or as vent and drain lines—to stay tight and flexible . . . *under even the severest vibration.*

You can get the *complete* assembly. American manufactures flexible metal tubing and fittings in a wide range of types and alloys.

You will find an experienced sales engineer in your area ready to discuss your flexible connector or shielding conduit problem with you. For easier production and better performance, send your connector details to: *The American Brass Company, American Metal Hose Branch, Waterbury 20, Conn. In Canada: The Canadian Fairbanks-Morse Co., Ltd.* 53219

ALSO—Ignition Shielding Conduit Assemblies, Shielding Conduit to Military Specifications, Flexible Metal Air Ducts, Exhaust Lines, Parachute Rip Cord Housings.

WHEREVER CONNECTORS MUST MOVE

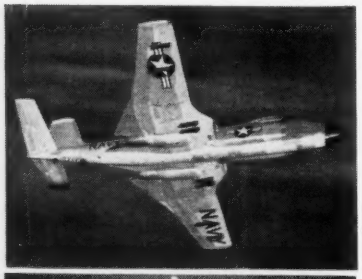
AMERICAN

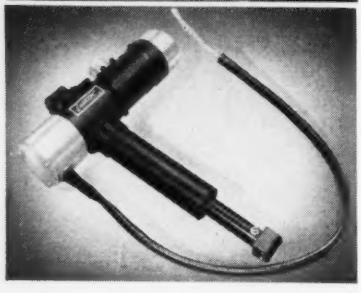
flexible metal hose and tubing

An ANACONDA® Product

ELEVATOR FEEL TRIM

Airborne Actuated on Navy's F2H-3





The elevator feel trim system in this McDonnell jet is actuated by Airborne's Model R-144M12-1 LINEATOR®. A ball bearing jackscrew enables this actuator to operate at 11 inches per minute with an 800 lb. load in either tension or compression.

The "T" type LINEATOR fits many situations where light weight and short length, for a given stroke, are desirable features.

Perhaps you have a similar application. Our literature in the I.A.S. Aeronautical Engineering Catalog gives detailed data on LINEATOR and other actuators manufactured by AIRBORNE.

AIRBORNE
ACCESSORIES CORPORATION
1414 Chestnut Avenue
Hillside 5, New Jersey

• **Brooks and Perkins, Inc. . . .** Frederick W. Seitz, who for 10 years has been a Director and Secretary of the corporation, was elected Secretary-Treasurer. At the same time, it was announced that Charles D. Smith is now Works Manager of the corporation's Mill Division at Livonia, Mich., and that Edward H. Perkins is now managing the newly established Commercial Division.

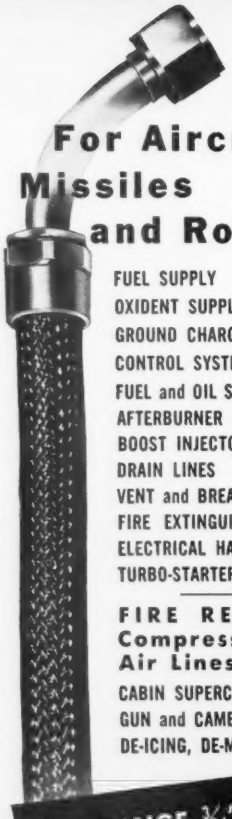
• **Chance Vought Aircraft Division, United Aircraft Corporation . . .** Ground was broken in June for a new $1,300,000 guided-missile hangar. This 65,000-sq.ft. building is being constructed to the rear of Chance Vought's main plant in Dallas and is scheduled for completion this coming January 1. After that date, Regulus missiles leaving the production line in the main plant will go to the new hangar for final installation of internal components, checking, and simulation of flight operations. Actual flights are conducted on the West Coast.

• **Consolidated Vultee Aircraft Corporation . . .** A template camera, measuring 29 ft. in length, is being used at Convair's San Diego Division to speed up engineering and tooling for various types of aircraft. This camera, designed largely by Convair graphic arts technicians, was built by Consolidated Photo-Engravers and Lithographers Equipment Company. It has a 12- by 5-ft. all-metal copyboard and three lenses—a 42-in. Goerz, a 36-in. Zeiss, and a 24-in. Zeiss—which produce enlargements to 4 times and reductions through a range of 1 to 13. This equipment can reproduce drawings with less than 0.002 in. in 12 ft. from the original. Drawing and lofting can be done in any scale desired. This equipment permits a precision model to be built to different scales without redrawing the master. Among the uses to which Convair is now putting the camera is the making of full-sized reproductions of air-frame structure for mock-ups on 1-in. plywood. . . . At a June meeting of the Board of Directors, Rear Adm. Lawrence B. Richardson, USN (Ret.), FIAS, Senior Vice-President of General Dynamics Corporation, and Frank M. Pace, Jr., Executive Vice-President of General Dynamics, were elected Vice-Chairmen of Convair's Board of Directors. It was also announced that August C. Esenwein was elected a Convair Vice-President. Mr. Esenwein will continue as Manager of the Fort Worth Division of Convair . . . Charles F. Horne, Rear Admiral, USN (Ret.), formerly Civil Aeronautics Administrator, has been named Manager of Convair's Pomona, Calif., Division. This appointment was effective July 15.

• **Cornell Aeronautical Laboratory Inc. . . .** Edwin M. Lindsay was elected Assistant Secretary of Cornell Laboratory at the June 12 semiannual Board of Directors meeting. At the same meeting, Dr. C. C. Furnas, FIAS, Director of the laboratory, reviewed the technical progress during the 1952-1953 fiscal year and stated that ". . .during the past few months a 3- by 4-ft. transonic throat has been developed which fits within the [laboratory's large wind] tunnel and permits testing of aircraft and missile models in the [transonic]

AVICA

LIGHTWEIGHT
CORROSION RESISTANT
Stainless Steel
FLEXIBLE
TUBE ASSEMBLIES



For Aircraft Missiles and Rockets

FUEL SUPPLY
OXIDENT SUPPLY
GROUND CHARGING
CONTROL SYSTEM UNITS
FUEL and OIL SYSTEMS
AFTERBURNER INSTALLATIONS
BOOST INJECTOR SYSTEMS
DRAIN LINES
VENT and BREATHER LINES
FIRE EXTINGUISHER SYSTEMS
ELECTRICAL HARNESS
TURBO-STARTER ASSEMBLIES

FIRE RESISTANT Compressor Bleed Air Lines for:—
CABIN SUPERCHARGING
GUN and CAMERA HEAT
DE-ICING, DE-MISTING

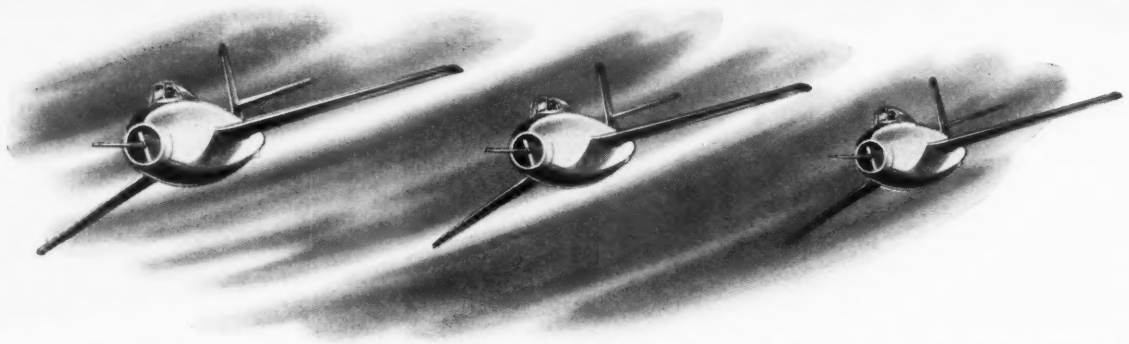
SIZE RANGE 3/16"—4" I.D.
MECHANICALLY *Applied*
Reusable END FITTINGS

AVICA is always ready to discuss special applications with customers and to develop hose assemblies to deal with unusual operating conditions.

WRITE TO SPECIAL PROJECTS DEPT. A. W. FOR FURTHER INFORMATION

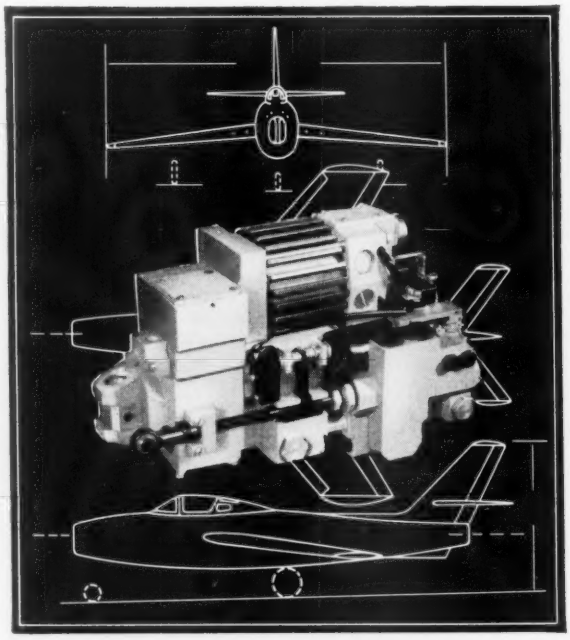
AVICA CORPORATION
P. O. BOX 1090
PORTSMOUTH, RHODE ISLAND
TEL. PORTSMOUTH 479

WEST COAST REPRESENTATIVE
AIRSUPPLY COMPANY, 9815 WILSHIRE BLVD.
BEVERLY HILLS, CALIFORNIA



AEROPRODUCTS ACTUATORS CONTROL "FLYABLE TAIL"

Self-locking features aid Republic's new F84F



Typical Aeroproducts Actuator

The broad adaptability of Aeroproducts actuators has helped to solve problems encountered in the design of the "flyable tail" of the new Republic F84F jet fighter. The application of these actuators permits instantaneous adjustment of a variable surface to any position within its design range. The self-locking feature of Aeroproducts actuators secures the adjustment until it is changed by the pilot.

Any combination of systems—hydraulic, pneumatic, electric or manual—can serve as the primary power source for Aeroproducts actuators. They can be synchronized readily in tandem or in series to provide coordinated control of related movements.

Announced uses of Aeroproducts actuators include those for the control of the "flyable tail" of the Republic F84F, the horizontal stabilizer on another high-speed jet fighter and the afterburner nozzle in a jet engine. Additional applications include control of wing flaps, dive brakes, bomb bay or cargo doors, gun turrets, variable wing sweep and incidence, wing fold and canopy slides.

Building for today
Designing for tomorrow

AEROPRODUCTS GM

GM GENERAL MOTORS

Aeroproducts

ALLISON DIVISION • GENERAL MOTORS CORPORATION
DAYTON, OHIO

This close-up view shows the new slotted helmet, designed and built by Douglas Aircraft Company, Inc., for emergency escape from aircraft flying at supersonic speeds. The development of this helmet was announced on June 25 by the USAF Air Research and Development Command. Further details may be found in the Douglas item on this page.

speed range. . . . This transonic throat achievement, coupled with the development of a 'Propeller Dynamometer' device for testing model propeller blades at supersonic speeds, now gives our large subsonic wind tunnel a remarkable versatility in overall operation."

• **Curtiss-Wright Corporation . . .** The Electronic Division is now designing and building an all-electronic simulator for the USAF's Boeing B-52 bomber. This division has so far delivered or designed simulators for the Boeing Stratocruiser, Boeing B-50, McDonnell 2F9, Boeing C-97A, Fairchild C-119, Douglas C-124, Convair B-36, Douglas DC-6B, and Convair 340.

• **Douglas Aircraft Company, Inc. . . .** The development of a new slotted helmet was announced on June 25 by the USAF Air Research and Development Command. This helmet, a close-up view of which is shown on this page, was designed and built by Douglas engineers with slots or vents in the forward crown section. These slots are for the purpose of reducing wind shock and air lift and of keeping the headgear secure to the head of a pilot forced to bail out from an airplane flying at supersonic speeds. This new slotted helmet has been successfully tested in an outdoor wind tunnel at simulated speeds up to Mach 1.04. Wind-tunnel tests conducted on a standard flight helmet and G-suit by Douglas engineers, working in cooperation with the ARDC, showed that the air rammed into the front of this type of helmet during a pilot's fall built up an internal pressure that soon became greater than the strength of the fittings that attached the helmet to the pilot; this resulted in the helmet's being blown off, thus leaving the pilot not only without protection from supersonic wind blasts but also without oxygen. To solve this problem, slots were cut into the helmet in the areas that showed up as negative pressure areas. These slots serve a dual purpose; first, to provide an avenue of escape for the internal air pressure and, second, to create a partial vacuum that helps hold the helmet firmly in place. As far as the G-suit was concerned, the wind-tunnel tests demonstrated that the air-blast loads tended to rip the G-suit apart around the chest zipper seams. Consequently, the G-suit was modified by stitching a reinforcing nylon vest to the suit and by relocating the zipper from the chest to the back. . . . The recently announced DC-6C, the new addition to the DC-6 series of transports, incorporates the special cargo facilities of the DC-6A Liftmaster and the passenger-comfort features of the DC-6B air liner. This new model is described "as the first commercial air liner specifically designed with a convertible cargo and passenger interior." The change-over from a configuration carrying 76 passengers and their baggage plus 2,400 lbs. of cargo to one carrying nearly 13 tons of cargo is reportedly accomplished in a matter of minutes by repositioning a movable bulkhead in four different stations. The passenger seats fold against the sides of the cabin when the plane is used as a cargo transport. Tourist- or coach-type buffet facilities for serving food and refreshments may be removed when no passengers are to be carried. The DC-6C, powered by four Pratt & Whitney R-2800 engines of the CB series, will have a cruising of more than 300 m.p.h.

• **Flight Safety Foundation, Inc. . . .** A new bimonthly publication entitled *Aviation Mechanics Bulletin* is being put out by Flight Safety. The first one was the May-June, 1953, issue.

• **General Electric Company . . .** The company recently announced a new method of testing G-E J-47 jet engines whereby the man-hours hitherto spent in testing can now be devoted to increasing actual production of engines, and the engine-running time, formerly expended in test cells, can be utilized in actual flight. It was also stated that this G-E-developed testing method has reduced the total manufacturing time cycle, with a corresponding increase in the turnover of engines in test cells. This new testing method has been under study for the past 3 years and was recently approved by the Air Materiel Command at Wright-Patterson AFB, Ohio. The plan has been made available to the aircraft-engine industry. . . . A Legal and Patent Department has been established in G-E's Aircraft Gas Turbine Division.

• **G. M. Giannini & Company, Inc. . . .** A new type pressure switch, Model 44517, is now in production. This unit, $2^1/_2$ in. in diameter, contains a pressure responsive element that actuates a switch that can be set at the factory to a predetermined pressure. This unit can be used in applications such as control-system actuation and/or pressure-warning or shut-off devices.

• **The B. F. Goodrich Company . . .** Two major divisions integrating sales, manufacturing, and necessary staff functions have been organized. These are: The B. F. Goodrich Company Tire and Equipment Division of which Arthur Kelly, a Vice-President of the company, has been named President; and the new B. F. Goodrich Company Industrial Products Division, of which Clyde O. DeLong has been named President. Mr. DeLong was formerly General Sales Manager of the old Industrial Products Division.

• **The International Nickel Company, Inc. . . .** John A. Marsh, Assistant Vice-President and Manager of Operating Department, has been elected a Vice-President of the company. Mr. Marsh is in general charge of all plant operations in the United States. . . . J. Roy Gordon was elected on June 16 Vice-President and General Manager of Canadian Operations of The International Nickel Company of Canada, Limited, succeeding the late R. Leslie Beattie in both capacities. (Mr. Beattie died suddenly on June 10.) Mr. Gordon had been an Assistant Vice-President since 1947 and Assistant General Manager of Canadian Operations under Mr. Beattie since May of 1952.

• **Lear, Incorporated . . .** A 26-volt d.c. intermittent-duty aircraft motor, series "BB," is now being produced in quantity by Lear. These motors can be used in any application that requires 5- to 45-watt output at speeds from 9,500 to 15,000 r.p.m. They are said to be particularly suitable for such devices as driving valves, shutters, flaps, trim tabs, positioning systems, and mechanical linkages through suitable gear-

Radar eyes see in darkness, storm, or fog

to lock this twin-jet fighter on its prey . . .

—the Douglas F3D Skyknight

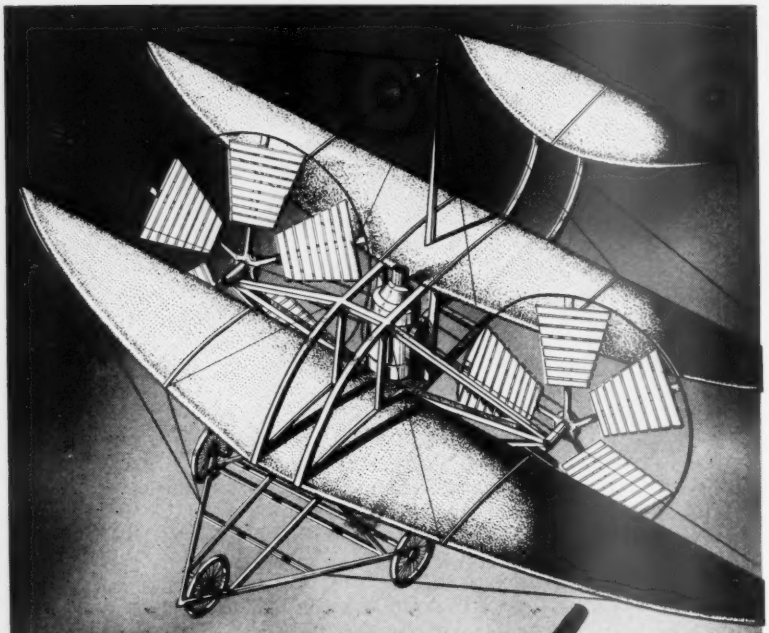
Out of Korea come new reports of the Douglas F3D Skyknight in action, downing Migs for the United States Marine Corps during advanced night and foul weather operations.

Designed for the U. S. Navy, the all-weather Skyknight flies at near-sonic speeds, operates from aircraft carriers as well as small advanced airfields. A side-by-side seating arrangement of pilot and radar operator results in closer combat teamwork—permits Skyknight's modern radar *search* and *fire control* equipment to be operated with maximum efficiency when against marauding enemy planes.

Performance of F3D Skyknight in action is another example of Douglas leadership in aviation. Planes that can be produced in quantity *to fly faster and farther with a bigger payload* are a basic rule of Douglas design.

Be a Naval flier—write to
Nav Cad Washington 25, D. C.

Depend on *DOUGLAS* **First in Aviation**



...out of this came Aviation

...a precision industry

To serve this great industry a manufacturer must maintain the best and most modern equipment available, operate it with skilled craftsmen, and use every existing method of tightening specifications and cutting production costs. Indiana Gear is such a manufacturer—a company of craftsmen producing fine quality transmissions and actuators for industry.

This is the control panel room in I. G. W.'s ultra modern heat-treating department—one of the contributing factors to Indiana Gear's unique ability to create hard-to-make parts to exacting specifications.

INDIANA GEAR

INDIANA GEAR WORKS, INC. • INDIANAPOLIS 7, INDIANA

ing. These totally enclosed "explosion proof" motors have a maximum diameter of 1.572 in. and lengths of 2.69, 3.00, 3.38, and 3.88. They were designed to meet the environmental and service requirements of Specification AN-M-40 and the new proposed MIL Specification for d.c. motors. Complete specifications of these small motors may be obtained through Lear's Contracts Division.

• **Lockheed Aircraft Corporation . . .** In an official ceremony at Lockheed on June 15, the turbocompound-powered Super Constellations received a CAA certificate qualifying them for "immediate public service." The Super Constellations earned their CAA ticket during a 48-day test period. All CAA tests were conducted at maximum take-off weight of 133,000 lbs.; on one test, the plane flew at 145,000 lbs. . . . An apron tough enough to stop a 0.38-cal. bullet fired from a distance of 8 ft. has been developed at Lockheed. Made of glass cloth laminated with a special polyester resin and weighing less than 3 lbs., these form-fitting aprons protect employees in Lockheed machine shops against flying metal particles that may spurt from high-speed milling and cutting equipment. These shield-like aprons, which are from $^3/_{32}$ to $^1/_8$ in. thick, are being manufactured for commercial use by B. F. McDonald Company, of Los Angeles, under license from Lockheed.

• **Loewy Construction Company, Inc. . . .** Three hydraulic Stretching and Detwisting Machines with a 750- to 1,500-ton capacity for aluminum extrusions have been ordered from Loewy-Hydropress, Inc. These machines will be operated in conjunction with a number of Loewy 8,000- and 20,000-ton Aluminum Extrusion Presses now under construction for the USAF Heavy Press Program.

• **North American Aviation, Inc. . . .** The one-thousandth T-28A trainer was delivered to the USAF from North American's Downey plant last June. . . . Robert A. Lovett, former Secretary of Defense, was elected a Director of North American at the June 19 meeting of the Board of Directors.

• **Northrop Aircraft, Inc. . . .** A method of inspecting transparent plastics has been evolved by Northrop plastics engineers. This method, using light projection and photography principles, requires equipment-wise a three-hold camera, a projector, and a grid system. In announcing this method, the company stated that it has been used to great advantage in the F-89 Scorpion for checking windshield side panels for distortion and that it is being further developed for similar use on canopies for the Scorpion. This system permits the amount of distortion of external images as would be viewed by the pilot to be determined before the panels are installed. The use of this new inspection method, it is said, has raised the acceptance rate of F-89 windshield panels to approximately 98 per cent. The method is also being adapted by Northrop as a checking system for the correction and development of forms, molds, and other types of tooling.

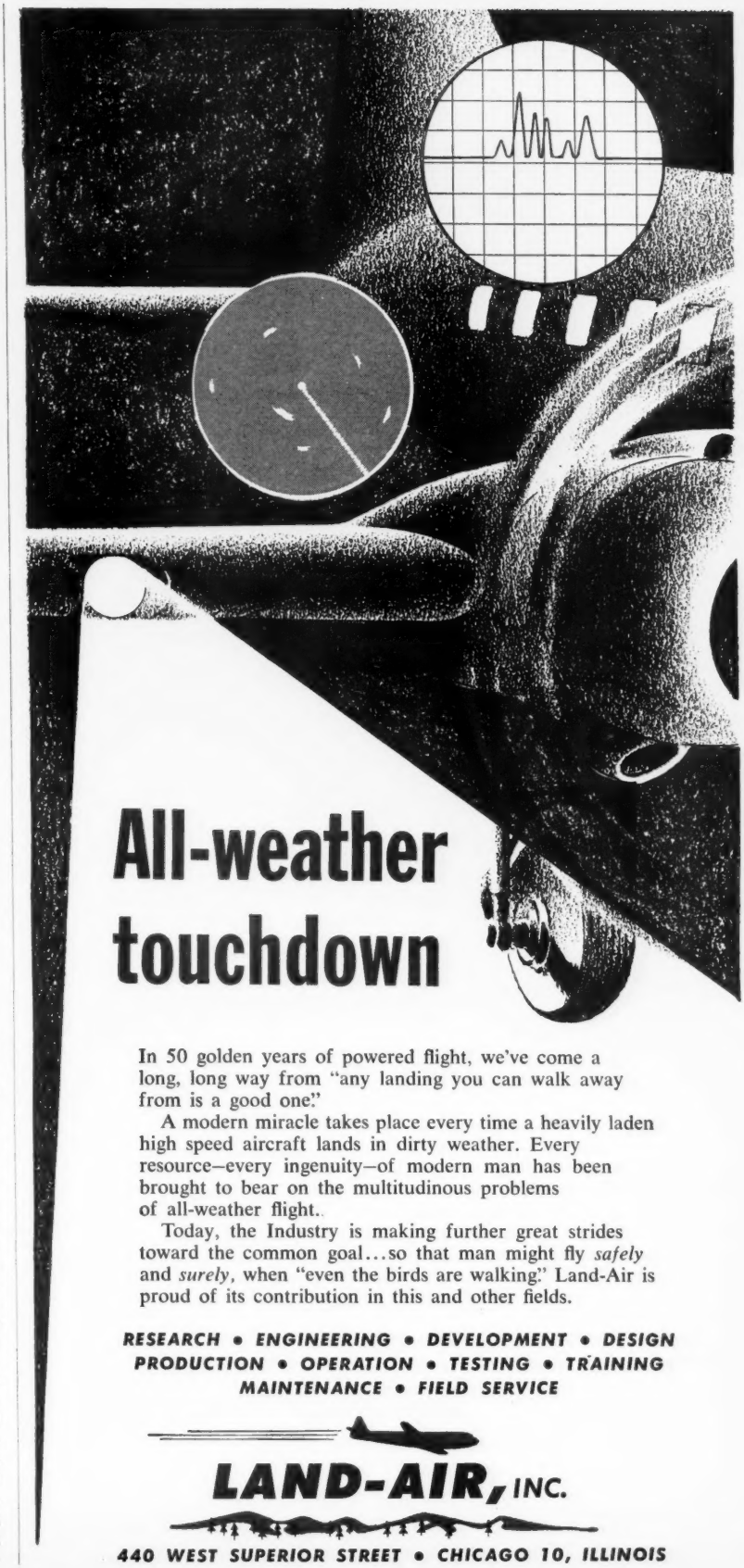
• **The Parker Appliance Company . . .** Effective last July 1, all of Parker's aircraft activity, exclusive of jet-engine

accessories, was consolidated on the West Coast. At that time, the firm's subsidiary, Parker Aircraft Company, of Los Angeles, took over all of the engineering, production, and sales activities of aircraft fuel- and hydraulic-system components. The Engine Accessories Division of Parker Appliance continues its manufacture of jet-engine components in Cleveland. This consolidation on the West Coast involved the transfer from Cleveland to Los Angeles of a considerable amount of production machinery, as well as a number of Parker executives and supervisors specializing in the aircraft field. The consolidation was preceded by Parker's recent purchase of the Proof line of aircraft hydraulic control valves and by the construction of a new research and development building to house Parker Aircraft's expanding engineering staff. The space in Cleveland released by this move is being used to expand Parker Appliance's output of industrial hydraulic accessories. . . . Effective the same date, July 1, the operations of another Parker Appliance subsidiary in Los Angeles, Synthetic Rubber Products, were merged with those of Parker Appliance's Rubber Products Division. This change in the official status of this facility, now known as the Rubber Products Division of Parker Appliance, in no way alters its function, and it is now operating the same as in the past.

• **Piasecki Helicopter Corporation . . .** An Army H-21C Work Horse helicopter recently made a flight from Philadelphia International Airport, carrying a useful load of 4,610 lbs. This is believed to be the heaviest load ever picked up by a rotary-wing aircraft. The H-21C flew at its normal gross weight of 13,300 lbs.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation . . .** The T-34 turboprop engine has been released by the U.S. Navy for commercial use. This commercial version, designated the PT2F-1, is rated at 5,600 hp. Pratt & Whitney is reportedly preparing for large-scale military and civil production.

• **Republic Aviation Corporation . . .** Legal formalities relative to the formation of an overseas subsidiary under Swiss law have been concluded, and Republic Aviation (International), S.A., is at present functioning from its offices at Lugano, Switzerland. The purpose of this subsidiary in Switzerland is to work under contract with United States Air Forces, Europe, to furnish spare parts for Republic's Thunderjet and Thunderstreak F-84's, which are now serving with the nine member nations of the North Atlantic Treaty Organization. The contract with USAFE is made under the Offshore Procurement Program. In manufacturing aircraft parts, Republic International is using production facilities in various European nations through subcontracts. All engineering, tooling, technical data, master tools, sample parts, and equipment to implement the program are being furnished by the parent U.S. corporation. Three members of the firm's New York administrative organization have been appointed to positions with the international subsidiary: John Gitz, General Manager; Eugene Kulesh, Contracts Administrator; and Karl Bohman, Secretary and Treas-


All-weather
touchdown
In 50 golden years of powered flight, we've come a long, long way from "any landing you can walk away from is a good one."
A modern miracle takes place every time a heavily laden high speed aircraft lands in dirty weather. Every resource—every ingenuity—of modern man has been brought to bear on the multitudinous problems of all-weather flight.
Today, the Industry is making further great strides toward the common goal...so that man might fly *safely* and *surely*, when "even the birds are walking." Land-Air is proud of its contribution in this and other fields.
RESEARCH • ENGINEERING • DEVELOPMENT • DESIGN
PRODUCTION • OPERATION • TESTING • TRAINING
MAINTENANCE • FIELD SERVICE
LAND-AIR, INC.
440 WEST SUPERIOR STREET • CHICAGO 10, ILLINOIS

urer. Republic Aviation is also maintaining offices in Paris where it is incorporated as Republic Aviation of France; its purpose is to coordinate administrative activities with representatives of NATO, USAFE, Mutual Defense Agency, and other defense headquarters.

• **Seaboard & Western Airlines, Inc. . . .** The corporation's DC-4 Hawaiian Airtrader carried in the early part of this summer 16,873 lbs. of mixed freight from New York to the British Isles and Western Germany. This was claimed by Seaboard & Western as a new record in transatlantic air transportation. The cargo included six young California sea lions and an equal number of small alligators from the Washington (D.C.) Zoological Society en route to the Hagenbeck Circus, Hamburg, Germany.

• **Simmonds Aerocessories, Inc. . . .** The new plant at Vergennes, Vt., for the manufacture of precision aircraft equipment had its official opening on last June 23. This building is the first of five units that are to be built on this site and which will eventually house the entire Simmonds' operation in the Vergennes area.

• **United States Aviation Underwriters, Inc. . . .** The Board of Directors recently announced the election of the following officers: Chairman of the Board, Reed M. Chambers, MIAS; President, Albert J. Smith; Treasurer, Lillian Rogers; Vice-President, Charles C. Compton; Vice-President, Lawrence Wilkinson; Vice-President, Woodrow J. Van Hoven; Assistant Secretary, Walter F. Peters; and Assistant Treasurer, Richard S. Brockway.

• **Vard Inc. . . .** Phillip R. Heim has been made Vice-President in charge of Manufacturing and a member of the Board of Directors at Vard. Mr. Heim has been associated with the corporation since 1950, first, as Production Engineering Consultant and, later, as Works Manager.

• **Vickers, Inc. . . .** The third Transport Aircraft Hydraulic Conference, sponsored by Vickers, will be held at the Park Shelton Hotel in Detroit, Mich., on November 3 and 4. The 1953 program will cover Transport Aircraft Hydraulic Systems in general, including accessories, tubing, fittings, and hydraulic fluids. Howard Pike, Chief Engineer for National Airlines, Inc., will act as General Chairman of this 1953 meeting.

• **Westinghouse Electric Corporation. . . .** A new Research Center in the electrical industry is now under construction on a 70-acre plot about 10 miles east of downtown Pittsburgh's Golden Triangle. It is scheduled for completion early in 1955. The new center will ultimately replace the present Westinghouse Research Laboratories located since 1916 only a few miles away from the new site.

Meet Your Section Chairman

Edmund C. Sulzman

Cleveland–Akron Section

An early interest in the technical aspects of aviation developments drew Edmund C. Sulzman into an aeronautical career. After working from 1926 to 1928 as a Draftsman for Worthington Pump Works and American Cirrus Engines, Inc., he joined Wright Aeronautical Corporation in a similar capacity.

In 1930, Mr. Sulzman interrupted his association with Wright Aeronautical to continue his education and entered Cornell University as a Freshman. Graduating in 1934 from Cornell as a Mechanical Engineer, he returned to Wright Aeronautical. Between then and 1951, he served successively as Test Engineer, Flight Engineer, Field Engineer, Assistant Chief Field Engineer, Chief Field Engineer, and, finally, Sales Manager. He left Wright Aeronautical in 1951 to assume his present position with Jack & Heintz, Inc., as Vice-President and General Sales Manager.

Mr. Sulzman, who is a native of Newark, N.J., has served on several NACA and USAF committees concerned with investigations of technical difficulties on military aircraft programs. The most interesting episode of his career, he tells us, was being involved in flight-test activities in connection with engine-installation investigations on such aircraft as the B-17, B-29, Boeing Clipper, Grumman F3F and F4F, Douglas DC-3, Lockheed Constellations, and various other aircraft. He has invented an automatic carburetor deicing system.

In addition to being an IAS Member, Mr. Sulzman belongs to the Wings Club, SAE, Air Force Association, Mid-Day Club, and the Cleveland (Ohio) Chamber of Commerce. His main recreation is golf. He and his wife, the former Evelyn Biche whom he married in 1935, are the parents of two boys, aged 8 and 15.

IAS Sections

Atlanta Section

Edith H. Lively, *Secretary*

The final meeting of the 1952–1953 season of the IAS Atlanta Section was held jointly with the local Section of the Society of Automotive Engineers on May 18 at the Atlanta Elks Club. SAE Chairman Karl H. Nonweiler presided. During the dinner, he introduced George W. Baughman, IAS Chairman, who in turn presented the other IAS officers of the Atlanta Section. Mr. Nonweiler then presented both the outgoing and incoming officers of the local SAE Section.

The speaker of the occasion was Richard L. Coffey, Allison Division, General Motors Corporation, who gave an excellent talk on turbojet and turboprop engines. A series of slides illustrated the address.

Mr. Coffey traced the development of the turbojet and turboprop from Sir Frank Whittle's gas turbine of 1930 through the Allison J33, J35, and J71 to the Allison T-38 and T40. He summed up the advantages of the turboprop engine as follows:

(1) The smallest turboprop being quantity-produced today has a slightly higher power rating than the largest reciprocating engine now in production.

(2) The decrease in power with altitude is less severe with a turboprop, and the turboprop will produce power at altitudes above the point at which a reciprocating engine is just self-sustaining.

(3) The forward motion of the aircraft and engine result in a ram effect that is advantageous to a turbine engine and of no effect, power-wise, to a piston engine.

(4) At extremely high speeds, the turboprop is now better than the piston engine at all altitudes.

(5) The turboprop is a relatively young engine, development-wise, with potential for economy refinements, whereas the piston engine has, for practical purposes, exhausted its possible refinements, as exemplified by: (a) The turboprop with half of the weight of the piston engine allows extra fuel to be carried for longer range operation or extra pay load to be carried for the same range. (b) The turboprop with a third of the frontal area of the piston engine permits improved aerodynamic wing and nacelle design with lower induced drag; consequently, the turboprop-powered version of a given aircraft design can fly faster at the same power setting or fly at the same speed with a lower power setting than could the piston-engine version.

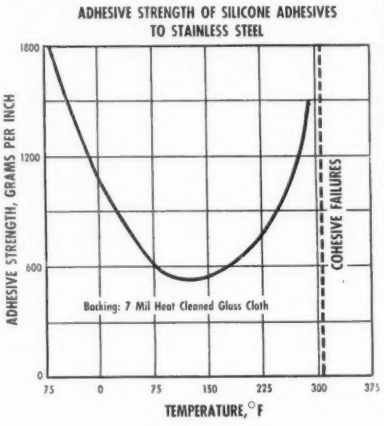
DOW CORNING

Silicone News

Vol. I, Number 1 • PUBLISHED BY DOW CORNING CORPORATION, MIDLAND, MICHIGAN

New Pressure Sensitive Silicone Adhesives Stick To Most Surfaces; Retain Their Excellent Adhesive Strength From -55F To Over 250F

The newest products to come out of our development laboratories are pressure sensitive silicone adhesives that stick to almost any materials including silicones and Teflon. Adhesive strengths in the range of 1800 grams per inch at —55 F and over 1200 grams per inch at 265 F, are far superior to those of conventional pressure sensitive tapes. The adhesive strength between a stainless steel surface and glass tape coated with silicone adhesives is plotted against temperatures ranging from —75 to 285 F in this Figure.



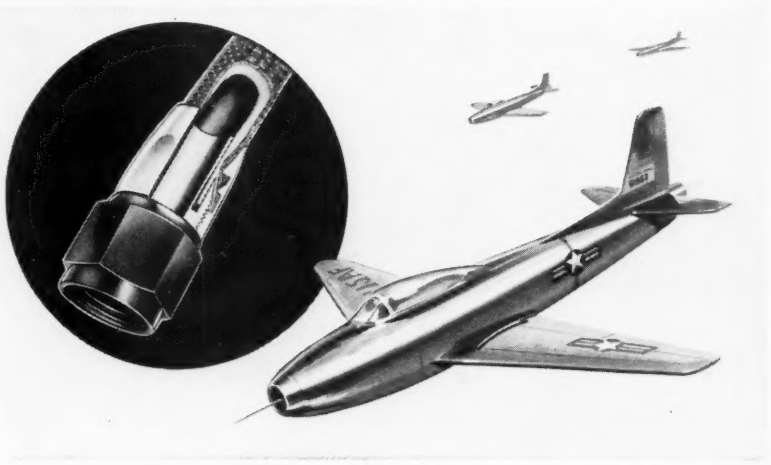
Uses for tapes coated with silicone adhesives include high temperature electrical and electronic applications; weather and moisture resistant wrapping and sealing tapes for low temperature applications. One electrical equipment manufacturer is already using these pressure sensitive adhesives to bond mica matt and integrated mica to glass cloth. *No. 1*

Silicone-based Aluminum Paints Outlast Organic Finishes 10 to 1 at Sterilizing Temperatures

Trays containing vials of aureomycin and other antibiotics at the Lederle Laboratories Division of American Cyanamid Company are loaded onto racks and sterilized for 3 hours at 446 F to destroy pyrogens.

The organic aluminum finish on these racks began to crack and peel, permitting rust to form, after 9 to 15

(*continued page 2*)



Flexible Silastic* Tubes Carry Air at 500 F; Prevent Engine Failure Due to Icing Over Jet Air Scoops

Reinforced with stainless steel braid, Silastic tubing requires minimum space; endures heat and high frequency vibration.

It was discovered shortly after certain jet engines were put into service that the formation of ice over air intake scoops could choke off the air supply and cause engine failure.

The obvious solution to this problem was to pipe air at 500 F from the compressor to the scoops. But that simple solution involved many problems.

The jet engines were so tightly fitted in their nacelles, that very little room was left for hot air ducts of any kind. High frequency vibration set up by the engine and plane introduced the problem of fatigue failure.

This was a job for a flexible tubing, a tubing that could carry hot air without melting, withstand the vibration and permit fast and easy assembly and disassembly. Engineers of the Aeroquip Corporation of Jackson, Michigan, solved the problem with flexible Silastic tubing. Reinforced with stainless steel braid, Silastic tubing is light and flexible. It is held mechanically to the stainless steel braid so tightly that the tube will not collapse even when subjected to a vacuum.

The high temperature problem of attaching a fitting to the hose was ingeniously solved by the new Aeroquip "Little Gem" fittings. The total assembly proved to be so effective that these anti-icing hoses have become standard equipment.

Despite internal and external temperatures as high as 500 F, the Silastic hoses are still in excellent condition after hundreds of hours of service. Aeroquip has supplied thousands of them to jet manufacturers. From 5 to 20 are required per engine, depending upon its design.

The usefulness of Silastic in this application confirms data collected by our development engineers on effects of accelerated aging at high temperatures on the properties of Silastic. Heat resistant organic rubber becomes brittle in a few hours; Silastic 80 does not crack on flexing over a ⅜ inch mandrel, and hardness increases only 9 points after more than 670 hours of continuous aging with all surfaces of the test sample exposed in an air circulating oven at 480 F.

Silastic 80 readily meets SAE-ASTM Specification TA805 which requires that it have a minimum tensile strength of 500 psi; a minimum ultimate elongation of 50 percent. After 70 hours aging in an air oven at 450 F, increase in hardness is not more than 15 points; drop in tensile strength is less than 25 percent and loss of ultimate elongation, less than 40 percent.

In oil resistance tests, decrease in hardness is less than 45 points; increase in volume, less than 60 percent after 70 hours immersion in ASTM No. 3 oil at 300 F. After 70 hours immersion in ASTM No. 1 oil at 300 F, loss in tensile strength and ultimate elongation is less than 20 percent; decrease in hardness,

(*continued page 2*)

*T. M. REG. U. S. PAT. OFF.

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING SILICONE NEWS PUBLISHED BY DOW CORNING CORPORATION

NEW DEVELOPMENT AND TECHNICAL DATA

For copies of any of the publications reviewed in this column or for data relating to any of the articles printed in this issue of the Dow Corning Silicone News, simply circle the corresponding reference number on the coupon below.

Expansible resins. Two new silicone resins, Dow Corning XR-543 and XR-544, can be expanded to produce heat-stable, non-flammable, unicellular foams with densities from 8 to 24 lbs per cubic foot. Highly resistant to thermal shock, these silicone foams show practically no structural or dimensional change after 20 hours at 700 F. Weight loss after 220 hours at 570 F is less than 2%; moisture absorption less than 0.05% after 7 days at 96% RH. Resins are easily foamed in place, made up as sandwich structures or machined with wood working tools. *No. 5*

•

Dow Corning 1109, a durable new silicone water repellent treatment for leather footwear, gloves, luggage and sporting goods; minimizes water absorption and transmission; improves resistance to oils and chemicals without changing the "breathing" characteristics of leather. *No. 6*

•

Now available, the new 1953-54 Reference Guide to Dow Corning Silicone Products summarizes properties and applications for commercially available silicones. A complete revision of previous guide which some designers have reported to be one of the most helpful catalogs ever produced. *No. 7*

•

Silastic 6-127 paste, an excellent cloth coating material and bonding agent for silicone rubber, retains good dielectric properties over a wide range of temperatures and frequencies. It has superior resistance to heat and moisture; remains flexible down to —100 F. *No. 8*

•

"Tall Tales and Fabulous Facts" is a new 24 page booklet built around the idea that, in our times, the tallest tales are told in technical terms. In this publication, the tall tales our ancestors told about such legendary characters as Paul Bunyan, Davy Crockett and Pecos Bill are related to some equally fabulous facts about Dow Corning silicone products. *No. 9*

•

Air drying silicone water repellent for application to glass, plastic and ceramic insulator bodies and to electronic parts and components maintains high surface resistivity under humid conditions; minimizes adhesion of dirt and chemical dust; reduces maintenance. *No. 10*

DOW CORNING CORPORATION - Dept. AI-9
Midland, Michigan

Please send me: 1 2 3 4 5 6 7 8 9 10

NAME _____

COMPANY _____

TITLE _____

CITY _____ ZONE ____ STATE _____

TECHNOLOGY DEPT. BUFFALO PUBLIC LIBRARY

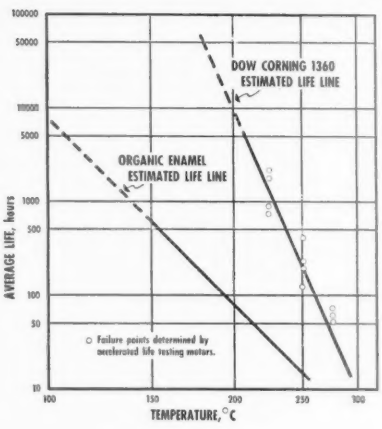
Small Electric Machines and Electronic Parts Can Now Be Designed to Operate at 180 C.

Life and reliability can be increased, or the size and weight of electronic devices and fractional or miniature motors can be reduced through the use of bare magnet wire insulated with Dow Corning 1360 Wire Enamel.

Flexibility, scrape hardness and dielectric strength compare favorably with those of the best organic wire enamels. Dow Corning 1360 coated wire also shows superior resistance to a wide variety of solvents, oils, and salt water.

The results to date of the accelerated life testing at temperatures in the range of 200 to 275 C of several electric motors wound according to standard commercial procedures with 1360 coated wire are plotted in the chart at right. These data show that motors wound with magnet wire insulated with Dow Corning 1360 Wire Enamel have a life in the range of 1500 hours at 225 C (437 F), compared with 30 hours for identical motors wound with the best grade of Class A wire.

Based on the results to date of this motor test program, we expect that the life of machines wound with 1360 coated wire at 180 C will be comparable to that of identical machines wound with conventional Class A wire at their maximum operating temperature of 105 C.


DOW CORNING 1360 ESTIMATED LIFE LINE
ORGANIC ENAMEL ESTIMATED LIFE LINE
AVERAGE LIFE, hours
TEMPERATURE, °C
○ Failure points determined by accelerated life testing motors.

Extrapolating from the data plotted above, we find that the life expectancy at 180 C of magnet wire insulated with this new enamel is in the range of 50,000 hours compared with 200 hours for wire insulated with the best organic enamels. *No. 4*

SILASTIC *continued*

less than 15 points. It shows no shrinkage and swell is less than 20 percent.

After 168 hours immersion in water at 158 F, swell is less than 10 percent and decrease in hardness is less than 10 points. It does not become brittle on continuous exposure at —65 F.

Silastic 80 offers another advantage in that it can be blended with Silastic 50 to fabricate parts having any Shore hardness between 50 and 80. These stocks can be blended to fabricate parts that meet SAE-ASTM Specification TA604. Heat-stable pigments can be used to give these stocks almost any desired color.

In electrical applications such as wire covering and cable coating, Silastic 80 retains excellent dielectric properties over a wide range of temperatures and frequencies. Cable insulated with Silastic 80 has a dielectric strength of 450 volts/mil at 50 C; 430 volts/mil at 250 C. *No. 3*

PAINTS *continued*

hours of such service. That introduced a costly hazard because any bit of rust or paint chips in a tray could cause rejection of a whole rack of carefully prepared antibiotics.

Some time ago, the racks were sand blasted, sprayed with a silicone-based aluminum paint. So far, the silicone finished racks have endured 150 hours at sterilizing temperatures with no sign of deterioration. As a result of that experience, Lederle is now using silicone-based paint to refinish sterilizing equipment throughout their plant.

At temperatures in the range of 500 to 1000 F. silicone-based aluminum finishes are used to protect stacks, exhaust mufflers, dryers, and furnaces. Modified silicone enamels in a wide variety of colors are used to protect appliances such as stoves, space heaters and incinerators at temperatures in the range of 400 to 700 F. *No. 2*

First in Silicones
DOW CORNING CORPORATION
Atlanta
Chicago
Cleveland
Dallas
Detroit
Midland, Michigan
Los Angeles
New York
Washington, D. C.
(Silver Spring, Md.)
In Canada: Fiberglas Canada Ltd., Toronto
In England: Midland Silicones Ltd., London

Manufacturers of—
Silicone Fluids
Silicone Abhesives
Silicone Adhesives
Silicone Release Agents
Silicone Compounds
Silicone Greases
Silicone Water Repellents
Silicone Bonding Resins
Silicone Electrical Insulating Varnishes
Silicone Molding Compounds
Expansible Silicone Resins
Silicone Defoamers
Silastic

A question-and-answer period, which followed the talk, was enjoyed by an audience of approximately 140.

Baltimore Section

R. W. Sanford, *Secretary*

The Forty-Fourth Meeting of the Baltimore Section was held in Levering Hall of The Johns Hopkins University on June 18 at 8:30 p.m. There were 93 members and guests present.

The speaker was Adm. Dewitt C. Ramsey, USN (Ret.). His subject was "Major Problems of the Aircraft Manufacturing Industry." Admiral Ramsey, who was graduated from the U.S. Naval Academy in 1912, has served in many important Naval Aviation assignments throughout his career. He became Naval Aviator No. 45 in 1917 and was given increasing responsibilities that culminated in his assignment as Commander in Chief of the Pacific and United States Pacific Fleet. Admiral Ramsey is now President of the Aircraft Industries Association of America, Inc.

Admiral Ramsey opened with a review of the achievements of The Glenn L. Martin Company and with the personal contributions of Mr. Martin, whose aviation career started in 1909. He emphasized the fact that the military budget for aeronautics is expected to be cut by $6,000,000,000 during the 1954 fiscal year, thus aggravating aircraft manufacturing problems. He further stated that, although the Aircraft Industries Association is not directly concerned with the military program, he had recently attended a meeting with Department of Defense leaders during which the following trends were discussed: Emphasis will be placed on combat aircraft, with fewer trainers; National Guard and reserve activity will be increased; a strong drive will be undertaken to tighten schedules and increase manufacturing efficiency; the aircraft production base will be narrowed and deepened; there will be no great letdown in aircraft production during the next 2 years; and, finally, a complete review and re-evaluation of air strategy and corresponding appropriations will be accomplished by the new Joint Chiefs of Staff.

Admiral DeWitt C. Ramsey, USN (Ret.), President, Aircraft Industries Association of America, Inc., addresses the Baltimore Section at its June 18 meeting.

Admiral Ramsey's views on aircraft manufacturing problems were highlighted under the following headings:

Research and Development.—Research and development activity has been at a low level in the past years in comparison with the level of activity within the U.S.S.R. There will be some cuts, but a high emphasis will be placed on promising projects. Radical changes in aircraft and equipment techniques are anticipated. Accomplishment of these changes requires a long lead time, throughout which it is essential to have substantial financial support.

Materials.—Basic materials are in good supply; however, new alloys are demanding large quantities of critical metals such as tungsten, chromium, and molybdenum, the availability of which will determine production rates. Substitutes for these critical metals are being discovered.

Titanium appears very promising for use in aircraft, but it is anticipated that the supply of titanium will not meet aircraft requirements until at least 1955.

Machine Tools.—Machine tools determine production rates. They are more important today than ever inasmuch as thinner sheets, harder materials, and closer tolerances are being used for modern aircraft. Manufacturing lead time for machine tools is 1 to 2 years; therefore, it appears necessary to plan on stock-piling machine tools in major aircraft plants.

Man Power.—The aircraft industry is the second largest in the United States, employing 700,000 people. There is a serious shortage of engineers and technicians which is emphasized by increasing complexity of high-performance aircraft. The B-47 has consumed 12,000,000 man-hours, whereas the B-29 required only 9,000,000 man-hours. Continuing engineering effort is required throughout production of military aircraft. During World War II, the ratio of engineering to shop personnel was 1 to 20. Today, this ratio has grown to 1 to 5. To supply the needs of industry, 30,000 engineers must be graduated from our technical colleges each year. Only 20,000 were graduated this year, and it is predicted that 17,000 will be graduated in 1955 as compared with 50,000 to be graduated in Russia during that year. There are excellent opportunities for engineers in the aircraft industry, and every effort should be made to obtain a sharp upturn in engineering training. As an example of the increased engineering effort associated with modern aircraft, it was pointed out that a World War II bomber design consumed 150,000 engineering hours. Today, a bomber design requires in the order of 3,000,000 engineering hours.

Guided Missiles.—Guided-missile activity is mounting in intensity and importance. Army Ordnance, Navy Ordnance, Navy Bureau of Aeronautics, and Air Force agencies are all working at a high tempo to develop effective missiles. The problems associated with missile development are similar to those associated with aircraft with increased emphasis on high-performance air frames and intricate control systems.

Transport and Cargo Aircraft.—Transport and cargo aircraft are a vital part of our air power. Ten-thousand C-47's were produced during World War II; however, new and outstanding advances are required in this field. A total of 38,000,000 ton-miles of freight were being carried yearly at the end of World War II as compared with 157,000,000 ton-miles in 1952. Admiral Ramsey agreed with the concept that the British are ahead of us in the transport field. The reason for this is that they started their jet-transport program in 1943 with heavy government subsidization. It is anticipated that we will close this gap within a few years, the main problem being to reduce power-plant costs.

Financial.—The aircraft industry has continually faced a difficult financial problem associated with meager profits and small dividends. Profit averages have been only 2 per cent of sales with less than 30 per cent paid in dividends. This represents only one-half of the profit level normally associated with other industry. It is essential that the military services allow more reasonable profits in order to attract necessary capital into the aircraft industry.

Cost Reduction.—Aircraft manufacturing cost reduction is being accomplished continually, but simplification in design is essential. Every effort should be made to design for producibility, as well as performance. In order to accomplish cost reductions, a long-range procurement program of at least 5 years is vitally needed. Preservation of basic pilot lines for aircraft and supporting industries should be accomplished on a long-term stabilized basis. This is insurance for which we pay a heavy premium, but in the long run it is the cheapest method for guaranteeing adequate availability of aircraft for military emergencies.

▶ The following officers have been elected for the 1953–1954 year: Chairman, George F. Towner; Vice-Chairman, J. Donald Rauth; Secretary,

DIALCO
for YOUR product
WHICH PILOT LIGHT DO YOU NEED?
THE BIG ONE
This Pilot Light Assembly was first made to accommodate the S-11 lamp and was intended for use in the cabs of great diesel locomotives.
ACTUAL SIZE
Cat. #613529-211
or
THE LITTLE ONE
The miniaturization program on defense products required the development of this sub-miniature light. It is used on communication equipment and aircraft. Midget flanged base bulbs to fit are rated 1.3, 6, 12, and 28 volts.
ACTUAL SIZE
Cat. #8-1930-621
Dialco HAS THE COMPLETE LINE of INDICATOR and PANEL LIGHTS
Samples to suit your own special conditions and requirements will be sent promptly and without cost. Just outline your needs. Let our engineering department assist in selecting the right lamp and the best pilot light for YOU.
Write for the Dialco HANDBOOK of PILOT LIGHTS
Foremost Manufacturer of Pilot Lights
DIALIGHT CORPORATION
60 STEWART AVENUE, BROOKLYN 37, N. Y.
HYACINTH 7-7600

Richard W. Sanford; and Treasurer, Robert L. Zouck. The Area Councilor is George S. Trimble, Jr. The following persons comprise the Advisory Board: A. J. Kullas, C. H. Niles, J. P. Paine, J. F. Maloney, F. D. Jewett, W. W. Bender, W. A. Bortner, and H. Pusin.

Boston Section

E. A. McBride, *Secretary*

"The Role of Aircraft Development Testing—from Preliminary Design to Production Line" was discussed by George D. Ray, Chief Preliminary Design Engineer, Bell Aircraft Corporation, at the Annual Dinner Meeting on May 26 at the Thomson Club, Nahant, Mass.

At 6:00 p.m., approximately 120 members and guests participated in a "What's Your Name Contest" during the social hour, sponsored by the Lynn Aircraft Gas Turbine Division of General Electric Company. The object of the contest was to identify the true names of twelve disguised persons who had been assigned such names as Mr. Air Frame, Mr. Jet Engine, etc.

Following the dinner, the contest winners were awarded prizes of lighters and automatic pencils. Joseph Whelton, of Raytheon Manufacturing Company, had the lucky number for the grand prize, a silver airplane lighter.

The newly elected officers were announced as follows: Chairman, J. D. Morrison; Vice-Chairman, J. J. Jerger; Secretary, E. L. Dashefsky; and Treasurer, E. A. McBride.

Professor R. L. Bisplinghoff, M.I.T., Outgoing Chairman, introduced Mr Ray, whose interesting talk before about 150 people covered some of the aircraft development testing procedures and problems encountered by Bell Aircraft Company. The talk was followed by a discussion period and the Shell Oil Company film, *Highlights of Farnborough 1952.*

Chicago Section

Charles L. Bonnette
Outgoing Secretary

On May 22, the Chicago Section held its annual and final meeting for the year at the Glenview Naval Air Station, north of Chicago, Ill. Approximately 90 members, their guests, and wives attended this meeting. At 5:30 p.m., transportation was furnished for a tour of the Naval Air Station. The tour was of great interest to the members and especially to their wives.

At 6:30 p.m., the members gathered in the Beachcombers Room of the Commissioned Officers Club for an informal social hour. This provided a fine opportunity for the members, their

PRESSURE SWITCHES

SAFETY-ENGINEERED

FOR *HIGH-SPEED* AIRCRAFT

RELIABLE SERVICE is paramount in pressure switch design. That's why rugged, precision-built Manning, Maxwell & Moore pressure switches are installed on many aircraft of all types today. They conform strictly to aeronautical engineering performance standards and pass exacting USAF specifications. The wide selection available includes these basic designs in single pole, double throw types:

FOR JET ENGINES — *High Static* pressure gauge or differential pressure switches.

FOR AIRFRAMES — *Low Static* pressure gauge or differential pressure switches.

FOR ROCKETS — *Hermetically-Sealed High Static* pressure gauge pressure switches.

All our pressure switches provide *flexibility of design* that permits adaptation to specific needs. We believe our unique design technique, years of experience in developing aircraft instrumentation, and extensive manufacturing facilities can be of real service to you. We are fully equipped to run exhaustive environmental and vibration tests in complete accord with the requirements for high-speed aircraft. Let us know your pressure switch application problems. Our engineering counsel is yours on request.

MANNING, MAXWELL & MOORE, INC.

AIRCRAFT PRODUCTS DIVISION • STRATFORD, CONN.

OUR AIRCRAFT PRODUCTS INCLUDE: TURBOJET ENGINE TEMPERATURE CONTROL AMPLIFIERS • ELECTRONIC AMPLIFIERS PRESSURE SWITCHES FOR ROCKETS, JET ENGINE AND AIRFRAME APPLICATIONS • PRESSURE GAUGES THERMOCOUPLES • HYDRAULIC VALVES • JET ENGINE AFTERBURNER CONTROL SYSTEMS.

GUNS... on the double!

Chase Assault Transports—the only planes capable of delivering heavy equipment to forward combat areas by ***landing*** in small, unprepared fields.

Gruelling Air Force-Army tests have proved this advanced engineering development which replaces—as the primary means of delivery—costly, uncertain techniques developed for interim use.

No time or weight penalty, no loss from chute malfunction or impact damage. Guns and vehicles are driven out of assault transports, intact, clean and ready for immediate service.

Chase AIRCRAFT CO., Inc.
WEST TRENTON, NEW JERSEY
STROUKOFF AVITRUC

wives, and guests to become acquainted. At 7:30 p.m., dinner was served in the main dining room. A background of organ music provided a pleasant atmosphere during the dinner.

At 8:30 p.m., the Chicago Section Chairman Dr. Harvard Hull opened the program of the evening by introducing Lt. and Mrs. Keith Boyer. Lieutenant Boyer represented the Naval Air Station as host for the evening's activities. He is an active member of the Chicago Section. The Commanding Officer, Capt. Ford Taylor, could not attend because of previous commitments, and Lt. Col. Harold Penne, Commanding Officer of the Marine Air Detachment and Treasurer of the Chicago Section, is now on active duty elsewhere. Dr. Hull continued by introducing the officers for the past year and their wives who were seated at the speakers' table. Last year's Chairman, Robert H. Wendt, and his wife were also seated at the speakers' table. Mr. Wendt is now Vice-President and General Manager of the Kiekhaefer Aeromarine Corporation, located in Fond du Lac, Wis.

The annual election of officers commenced with the report of the proposed slate from the Nominating Committee. After Robert Saff, the Acting Chairman for this group, had read the proposed slate, a motion was made and seconded from the floor to accept it as read. A unanimous vote officially elected the following officers into service: Chairman, Alfred F. Stott; Vice-Chairman, Charles L. Bonnette; Secretary, Leland W. Sims; and Treasurer, Orland J. Engle.

The newly elected Chairman Alfred F. Stott thanked the group for the vote of confidence and immediately assumed his duties by accepting the gavel from the past Chairman, Dr. Harvard Hull. Mr. Stott then called attention to a sizable group of Student Members and their guests representing The Aeronautical University, Inc., and the Navy Pier Branch of the University of Illinois.

A highlight of the evening came as Mr. Stott, in behalf of the supporting officers for the past 4 years, presented certificates of gratitude to the Chairmen who have guided the Chicago Section during the first 4 years of its existence. Each certificate was signed by the Vice-Chairman, Secretary, and Advisory Board Chairman for each respective year. The four Chairmen, in order of their service, are: Dr. Harold Hawkins, who was most active in founding this Section; Kenneth Burrows; Robert Wendt; and Dr. Harvard Hull.

The evening's activities were concluded with the presentation by Lieutenant Boyer of two interesting Navy films.

MILLIONS OF HOURS AHEAD
in lightweight turbo-machinery!

Today, AiResearch has a backlog of *25 million hours of actual operating field experience* in lightweight turbines. These units provide auxiliary power, starting power, pressurization, heating and refrigeration for U. S. aircraft. With rpm's ranging from 10,000 to 100,000, average efficiency is 83%.

The many thousand AiResearch turbine machines now in operation are the result of a pioneering development and manufacturing program begun 9 years ago. In its course more than 2 and ¼ *million* hours were spent in engineering development, plus over 100,000 hours of laboratory tests.

This *experience* where others are still exploring is typical of AiResearch leadership in the small but highly efficient power and control units required in the many fields of modern industry.

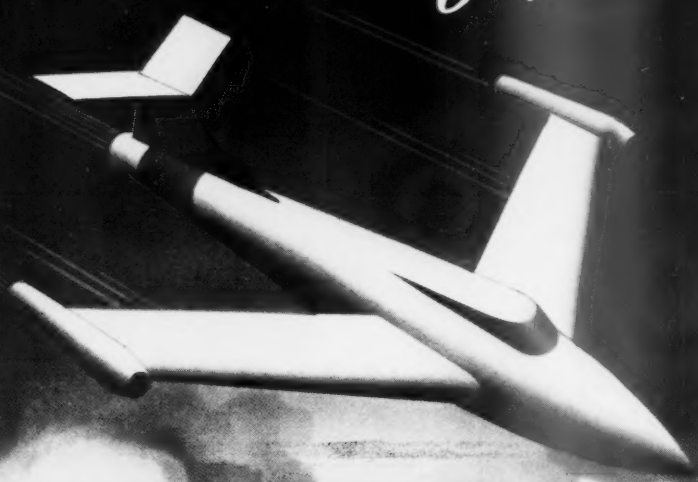
AiResearch Manufacturing Company

A DIVISION OF THE GARRETT CORPORATION

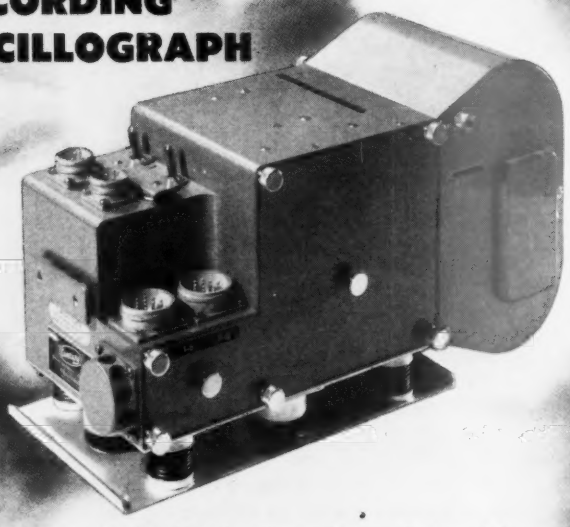
LOS ANGELES 45, CALIFORNIA • PHOENIX, ARIZONA

AiRESEARCH—specialists in the design and manufacture of aircraft accessories in the following major categories: air turbine refrigeration • cabin superchargers gas turbines • pneumatic power units • electronic controls • heat transfer equipment • electric actuators • cabin pressure controls and air valves

STABILITY *in flight*



RECORDED ACCURATELY By Century Model 409 RECORDING OSCILLOGRAPH



The Century Model 409 Oscillograph was designed for operation under the most adverse conditions, especially where space and weight considerations are limited. It is a miniature, compact unit incorporating many features found in larger models. Records faithfully during accelerations and shock in excess of 20 G's. Its size and capacity make it especially desirable for use in missile launching, parachute seat ejection, flight test of helicopter and fighter aircraft and torpedo studies.

Century GEOPHYSICAL CORPORATION
TULSA, OKLAHOMA
4447 No. Bodine · 3406 W. Washington Blvd. · 238 Lafayette St. · 309 Browder St. · EXPORT OFFICE
Philadelphia 40, Pa. · Los Angeles 18, Calif. · Dayton 2, Ohio · Dallas, Texas · 149 Broadway, N. Y. City

Columbus Section

S. A. Gordon
Outgoing Secretary

The following officers were installed on June 1: Chairman, M. M. Blair; Vice-Chairman, A. G. Winnett; Secretary, Emerson Smith; and Treasurer, R. F. Badertscher. C. J. Gallant is the Area Councilor. The members of the Executive Board are: D. T. Williams; Comdr. A. L. Petitjean, USN; Sam Gordon; G. R. Gehrkens; W. T. Butterworth; and G. A. Page, Jr.

Hampton Roads Section

H. Herbert Jackson
Outgoing Recording Secretary

On June 17, 36 members and guests of the Hampton Roads Section were treated to a showing of an NACA 40-min. sound and color film entitled *Airplane Crash Fire Research*. William V. Gough, Head of Flight Operations, NACA Lewis Flight Propulsion Laboratory, introduced the film and served as moderator during a question period following the film.

The crash-fire research covered by the film began in 1949 at the Lewis laboratory. Mr. Gough pointed out that investigations of crash-fire accident records failed to reveal well-defined mechanisms for crash fire, primarily because the pertinent physical factors acting to initiate the fire were often obscured from view or were too short lived to be reported by eye witnesses. As was pointed out by the film, this was not the case in the NACA crash-fire research.

The film showed that in long-range studies of the crash-fire problems, using service-weary twin-engined aircraft of the C-46 and C-82 type, the Lewis laboratory has obtained a much clearer understanding of the mechanism of the aircraft crash fire—why and how a fire starts and spreads—thus enabling a better appreciation of important factors in the problem heretofore not fully recognized. At the same time, the actions of fire-extinguishing agents and experimental inerting systems have been studied more fully.

The tests simulated unsuccessful take-offs and landings of full-scale aircraft and were devised to give surge fuel spillage and high incidence of fire. A couple of previously hidden ignition sources disclosed by the tests were the high charge of static electricity which may build up as the crashed airplane slides along the ground and the hot friction sparks that may be generated as the metal fuselage skids along a concrete runway.

Following the discussion period after the showing of the film, a business meeting was held during which the officers

and Advisory Board members for 1953–1954 were elected. Those elected were: Chairman, H. Herbert Jackson; Vice-Chairman, Carl A. Sandahl; Treasurer, Robert E. Pendley; Corresponding Secretary, Emanuel Boxer; and Recording Secretary, John E. Duberg. The Advisory Board includes H. J. E. Reid, John Stack, J. A. Roche, and C. H. Zimmerman. Appointments of committee chairmen will be announced later.

A *Hampton Roads Section Register and Scrapbook* was displayed for the first time at this meeting. The "Scrapbook" covers the history of the Hampton Roads Section from its beginning.

Los Angeles Section

Harold S. Fischer, *Secretary*

In conjunction with the Aero-Medical Engineering Association, the Los Angeles Section of the IAS held its monthly dinner meeting on June 23. Approximately 200 people attended. "Escape from High Speed Aircraft" was the topic of the principal speaker, Major Vincent Mazza, Aero-Medical Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. Prepared comments were given by Dr. John R. Poppen, Consultant in aviation medicine, Douglas Aircraft Company, Inc., and I. H. Culver, Department Manager, Missiles Division, Lockheed Aircraft Corporation.

Major Mazza is well known for his pioneering in ejection-seat aircraft bail outs. A color film was shown of actual bail outs performed by Major Mazza and his group.

Many bail outs were made at transonic speeds, where the unknown effects of 500 to 600 m.p.h. wind forces on the human body provided serious hazards. Major Mazza subjected himself to these conditions, which included the escape problem resulting from the low pressures and extreme cold of 30,000- to above 40,000-ft. altitudes.

This work is a dramatic part of a continuing study on escape from high-speed and high-altitude aircraft being carried on by the Aero-Medical group at Wright Field. Major Mazza has been intimately associated with this group since the end of World War II.

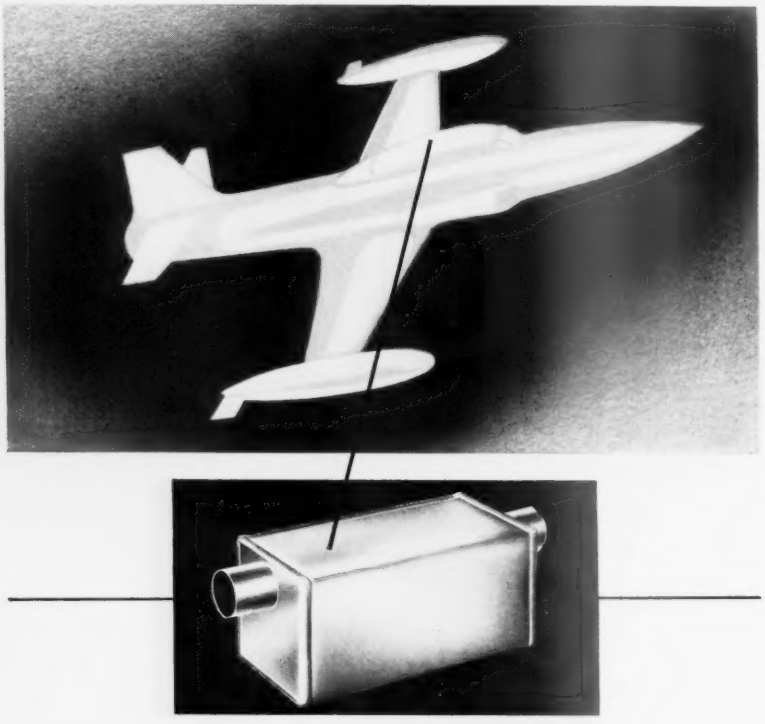
Philadelphia Section

Emily Rogers Gibbs, *Secretary*

The final dinner and meeting of the 1952–1953 season was held at the Penn-Sheraton Hotel on June 3.

The retiring Chairman, Harry Tobey, announced the election of officers and Council for 1953–1954. The officers are: Chairman, Dale Hamilton; Vice-Chairman, Alfred Little, II; Treasurer,

LORD ... Supplier to
THE AUTOMOTIVE AND AVIATION INDUSTRIES
for 25 Years...
LORD Mounts have become a vital part of the Automotive and Aviation Industries during the past quarter century. The vast reservoir of experience as a prime supplier is of great practical value to design engineers of today. Thousands of Lord Mounts protect the most sensitive instruments and the most rugged of component parts from shock and vibration.
Shown here are a few typical Lord applications used in wide diversity in the industry. We welcome the opportunity to help you with your shock and vibration problems.
SAE National Aeronautic Meeting, Hotel Statler— Booth No. 21, Los Angeles, California Sept. 29–Oct. 3, 1953
BURBANK, CALIFORNIA 233 South Third Street
DALLAS, TEXAS 413 Fidelity Union Life Building
PHILADELPHIA 7, PENNSYLVANIA 725 Widener Building
DAYTON 2, OHIO 410 West First Street
DETROIT 2, MICHIGAN 311 Curtis Building
NEW YORK 16, NEW YORK 280 Madison Avenue
CHICAGO 11, ILLINOIS 520 N. Michigan Ave. Room 811 Hanna Bldg.
CLEVELAND 15, OHIO
LORD MANUFACTURING COMPANY • ERIE, PA.
LORD BONDED RUBBER
Headquarters for VIBRATION CONTROL



New **ISC HIGH VELOCITY AIR LINE MUFFLER WHIPS JET COCKPIT WHINE**

The shrill whine of cockpit air conditioning equipment is a threat to pilot comfort and ease of communications. Now, ISC has solved this annoying problem with a midget, lightweight muffler which fits easily into any existing aircraft air conditioning system.

Giving up to 20 decibels broad band attenuation, the ISC High Velocity Air Line Muffler measures only 5" square by 10" long and weighs only 3½ pounds.

Constructed of steel-lined aluminum, it is rugged as well as compact. It will operate at temperatures of 500° F and above. Incorporating the Soundstream principle, the muffler produces amazing noise reduction with only a minimum pressure drop.

The High Velocity Air Line Muffler is another ISC FIRST in the field of aviation sound control. Why not bring YOUR noise problem to ISC now!

For further details on the ISC High Velocity Air Line Muffler, write to:

ENGINEERING DEPT.
INDUSTRIAL SOUND CONTROL, INC.
45 GRANBY STREET,
HARTFORD, CONN.

SILENCE SERVICE

Industrial Sound Control Inc.

45 Granby Street, Hartford 12, Conn.

2119 SO. SEPULVEDA BLVD., LOS ANGELES, CALIF.

Louis Clark; and Secretary, Emily Rogers Gibbs. The Council members are: G. M. Bellanca, Richard H. Prewitt, Charles R. Barnett, Thomas R. Pierpoint, Samuel Berkowitz, John Kean, Michael Stroukoff, Edward Seckel, Harold Lemont, and Harry Tobey.

Captain Paul J. Burr, USN, Head, Air Branch, Office of Naval Research, Department of the Navy, substituted as the speaker of the evening for Rear Adm. Calvin Bolster, Chief of Naval Research. Admiral Bolster, who was required to appear before a Congressional committee for appropriations, sent his regrets via Captain Burr.

Captain Burr introduced the topic, "Current Research Trends in Naval Aviation," by outlining the four major tasks of the Navy. These are: (1) the security of overseas transportation; (2) Naval striking power; (3) amphibious operations; and (4) defense of the North American continent from attack through sea approaches.

The first task is the problem of protecting our country's shipping from three major threats—enemy submarines, mines, and aircraft. A vigorous research and development program for antisubmarine warfare is being prosecuted.

In the second task, that of Naval striking power, Captain Burr explained the strike potential of the carrier task force and the problems engendered in the intelligent assimilation of all information that must be received by a carrier command center from aircraft, picket submarines, ships, radar and underwater sound equipment. He also indicated how the effective employment of this information depends upon the form in which it is provided to responsible commanders for decision making.

In connection with amphibious operations, he pointed out that this is the principal means by which the surface, subsurface, and air potential of the fleet may be extended to establish and maintain a foothold in almost any area in the world. The research effort in this category is being directed toward better ships, aircraft, vehicles, weapons, and equipment for amphibious attack. Greater increases in the speed of landing craft must be attained in order to concentrate troops, from widely dispersed ships, on to a beach within a matter of minutes rather than hours.

The fourth important responsibility, the defense of the North American continent, becomes more critical as the Russian capability to wage atomic warfare increases. It is here that close collaboration in other departments, particularly that of the Air Force, is being emphasized in order to establish an overall continental defense system. Reference was made to Project LINCOLN, a research group at the Massachusetts

THE HISTORY OF AIRCRAFT HEATING PROGRESS

has been written by

South Wind

REG. U. S. PAT. OFF.

From the beginning, South Wind has been the pioneer and leader in the development of aircraft heating equipment combining unfailingly dependable performance with simplified design and installation, utmost safety, minimum maintenance requirements.

The research, engineering, testing and production facilities thus developed are unique in the industry. They are at your disposal to help solve your most challenging heating problems for military, commercial or civilian aircraft.

Write today for information. South Wind Division, Stewart-Warner Corporation, Indianapolis 7, Indiana. In Canada, Stewart-Warner of Canada, Ltd., Belleville, Ontario.

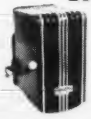
South Wind

REG. U. S. PAT. OFF.

AIRCRAFT HEATING AND THERMAL ANTI-ICING EQUIPMENT
INERT GAS GENERATORS

A PRODUCT OF SW STEWART WARNER

Milestones in the March of Progress



1936 First Production Combustion Type Vehicle Heater
South Wind Model 781, 6,000 BTU/hr.

1941 First Production Combustion Type Aircraft Heater
South Wind Model 789, 8,500 BTU/hr.; Model 790, 80,000 BTU/hr.; Model 791, 40,000 BTU/hr.

1943 South Wind Model 900, 200,000 BTU/hr.

1943 South Wind Model 911, 160,000 BTU/hr.

1944 South Wind Model 906, 50,000 BTU/hr.

1944 South Wind Model 912, 175,000 BTU/hr.

1944 South Wind Model 917, 25,000 BTU/hr.

1945 South Wind Model 920, 100,000 BTU/hr.

1945 South Wind Model 921, 200,000 BTU/hr.

1945 South Wind Model 979, 18,000 BTU/hr.

1945 South Wind Model 68077, 800,000 BTU/hr.

1945 South Wind Model 919, 290,000 BTU/hr.

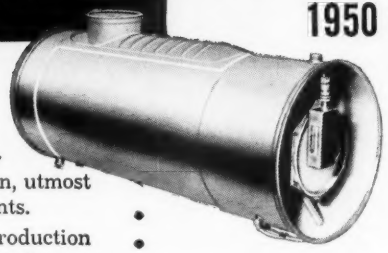
1946 South Wind Model 918, 400,000 BTU/hr.

1948 South Wind Model 930, 100,000 BTU/hr.

1949 South Wind Model 910, 235,000 BTU/hr.

1949 South Wind Model 929A, 700,000 BTU/hr.

1950 South Wind Models 995, 996, 999, Inert Gas Generators



1951 South Wind Model 960, 25,000 BTU/hr.

1952 South Wind Model 997, Inert Gas Generators

1952-1953 South Wind Model 929C, 600,000 BTU/hr.

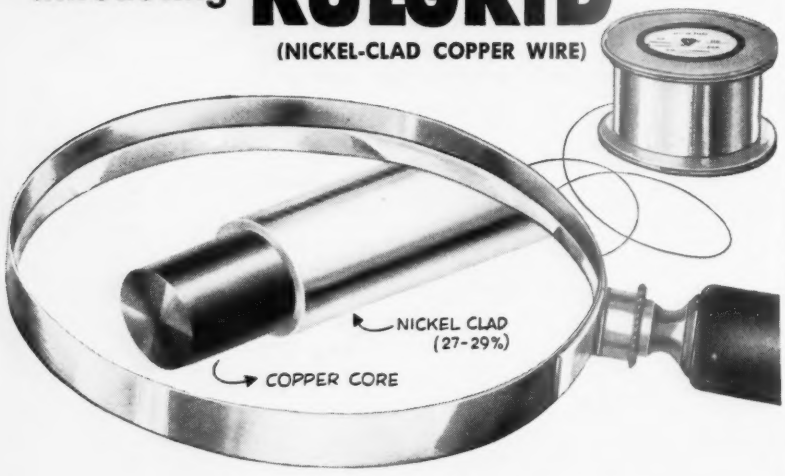
Participating in this March of Progress . . .

South Wind products have been used in aircraft or equipment manufactured by:

Beech Aircraft Corporation
Bell Aircraft Corporation
Boeing Airplane Company
Cessna Aircraft Company
Chrysler Airtemp Construction Co.
Consolidated-Vultee Aircraft Corp.
Curtiss-Wright Corporation
Douglas Aircraft Company, Inc.
Fairchild Engine & Airplane Corp.
Grumman Aircraft Engineering Corp.
Hughes Aircraft Company
Lockheed Aircraft Corporation
Glenn L. Martin Company
North American Aviation, Inc.
Northrop Aircraft, Inc.
Piper Corporation

Introducing **KULGRID**

(NICKEL-CLAD COPPER WIRE)



...today's best answer to high temperature electrical-conductive problems

Electrical engineers in many industries now give Sylvania's Kulgrid the highest rating. This improved nickel-clad copper wire maintains excellent electrical conductivity at advanced temperatures. Its heavy nickel coating resists corrosion and guards the copper conductor against oxidation, flaking, brittleness or deterioration.

IDEAL FOR MANY APPLICATIONS

Kulgrid shows exceptional stability and performance in the high temperature operation of vacuum tubes. Other applications include: wiring of electric furnaces, industrial baking ovens, electric stoves, and numerous aircraft electrical installations, including jet engines.

AVAILABLE IN STRANDED FORMS

You can now obtain Kulgrid in stranded forms in various combinations of diameters and numbers of strands. Kulgrid welds readily to itself, nickel, copper, and can be welded to tungsten and molybdenum. New illustrated booklet gives detailed data. For your copy, address: Sylvania Electric Products Inc., Dept. 3A-5909, 1740 Broadway, New York 19, N. Y.

SYLVANIA

LIGHTING • RADIO • ELECTRONICS • TELEVISION

In Canada: Sylvania Electric (Canada) Ltd., University Tower Building, St. Catherine St., Montreal, P. Q.

Institute of Technology doing research in this area.

Captain Burr then explained briefly the organization of the Office of Naval Research, including the way in which it conducts a basic-research program and maintains active liaison with the Fleet and material bureaus in order to be alert to those needs of the fleet which can be served by research. He also explained the value of having in ONR personnel with such diverse backgrounds and spheres of interest as possessed by scientists, physicists, mathematicians, psychologists, engineers, and Naval officers in almost all the different categories.

He then spoke in more detail of the ONR program in support of Naval aviation and how ONR provides the early information upon which the Material Bureau's research and development depend. This program includes projects in Naval air-warfare systems, in aircraft weapons systems, and in research for higher performance airplanes (particularly the launching and landing capabilities that are so important to carrier-based aircraft, aircraft instrumentation, balloons, and helicopters). It was pointed out that research effort is devoted to handling equipment of carriers, as well as to the airplane slow-speed performance capability. Important in this area are boundary-layer control and circulation control. It was interesting to hear that ONR has begun a research project to develop a better method of aircraft instrumentation. Here, a new concept is conceived wherein the pilot will be furnished with only the information he needs and in such a manner that it can be readily assimilated by him without requiring tedious and difficult mental computations. The need for research on free balloons was outlined. Particularly significant is the fact that a balloon is the only means now available to provide an observation station at extremely high altitudes for an extended length of time. This enables measurements of cosmic-ray activity and of the jet-stream phenomenon and permits an extended examination of the upper atmosphere in order to improve weather prognostication.

ONR's research on helicopters is directed mainly toward stability and control problems and consists, among other things, of support of a track-type helicopter rotor testing facility at Princeton University, research on helicopter automatic-control systems, and a variable-parameter research helicopter for which Kellett Aircraft Corporation has a research contract.

After the close of the talk, a film, *Ski Jump II*, was shown. This film told the story of an ONR expedition to the Arctic for the purpose of adding to the geophysical knowledge of the Arctic.

This expedition was serviced by Naval aircraft landing on skis in extremely difficult snow-and-ice conditions. This film demonstrated effectively how aviation can be of service to research.

San Diego Section

Earl R. Hinz

Corresponding Secretary

The June activities calendar for the San Diego Section included a technical meeting and a dinner meeting. The technical meeting, held on June 16 at the IAS Building, had as its topic the development of antennas for high-speed aircraft. Dr. William J. Schart, a Design Specialist for Consolidated Vultee Aircraft Corporation, presented his talk and supplemented it with antenna exhibits and slides.

The use of external antennas on high-speed aircraft has become prohibitive because of high aerodynamic drag and the almost impossible structural requirements. As a result, recent antenna research has been directed toward the design of flush-mounted antennas. These antennas thereby become a part of the aircraft structure, and the antenna designer finds himself a combined aerodynamics, structures, and electronics engineer. The various exhibits displayed by Dr. Schart illustrated some of the design and manufacturing techniques presently employed.

▶ A special dinner meeting was held at the IAS Building on June 25. After the dinner, members and guests assembled adjacent to the IAS Building, at the pier of the San Diego Speedboat Club, where they were met by Navy launches for a field trip to the Naval Air Station across San Diego Bay.

Arriving at the Engine Overhaul Shops of the Overhaul and Repair Department, the IAS group was met by Capt. George A. Hatton, USN, who served as host for the evening. Picked Naval and civilian personnel described the task and functions of the shops and then guided small groups of IAS members on tours of the engine-overhaul facilities. The San Diego Naval Air Station is designated a major engine-overhaul base, and, consequently, a wide variety of reciprocating and jet engines were seen in several stages of overhaul. Each group also witnessed a run-up of a jet engine in a test cell, with the operator explaining the instrumentation that was being used.

The members and guests present expressed complete satisfaction with the fine program presented by the Naval Air Station which was in keeping with the traditionally successful joint Navy-IAS undertakings in San Diego.

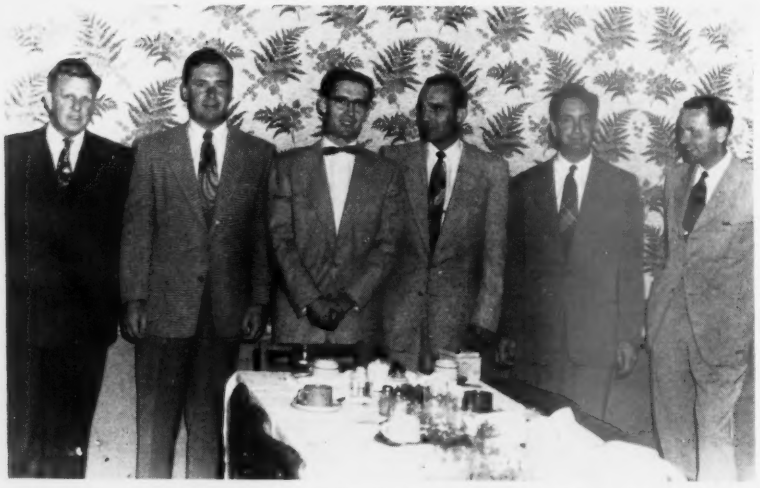
Student Branches

Academy of Aeronautics

Ken O'Connor, *Secretary*

At the meeting of June 10, the Paper and Pen Committee announced the winner of the IAS Awards. Jerome Cohen received the Scholastic Award, while Marvin Greenberg won the Lecture Award with his student paper on "A Comparison of British and American Aircraft Industries." A film from Boeing Airplane Company, *Theory of Flight*, was shown. Chairman George Ludwig presided.

BECAUSE OF THE NAIL THE BATTLE WAS LOST
WINNING THE BATTLE with component parts
Unlike the proverbial horseshoe nail that *lost* the battle, today's military aircraft *win* battles because of the quality of their *components.*
Where specifications demand precision machining, quality stamping, dependable certified heliarc or continuous seam welding, or tooling, major aircraft manufacturers invite UNIVERSAL to bid.
A major west coast production facility, UNIVERSAL offers long experience in the priceless "know how" that is so important in turning out quality in volume and guaranteeing "on-schedule" delivery — at competitive prices.
Write for our new facilities brochure . . . let us bid on your requirements. Nationwide service.
UNIVERSAL METAL PRODUCTS, INC.
Tools • Dies • Metal Stampings • Aircraft Parts
Serving America's Aircraft Industry
2311 West Orange Street
Cumberland 3-3115
Alhambra, California



This picture, taken at the 1953 Annual Spring Banquet of the California State Polytechnic College, shows some of the honored guests and the incoming and outgoing chairmen of the Cal Poly Student Branch. *From left to right*, are: L. W. Gustafson, Head, Aeronautical Department, Cal Poly; Harold P. Hayes, Dean of Engineering, Cal Poly; V. Keith Putnam, Outgoing Student Branch Chairman; Robert G. Garrison, Incoming Student Branch Chairman; Philip A. Colman, Chief Aerodynamics Engineer, Lockheed Aircraft Corporation; and E. W. Robischon, IAS Western Region Manager.

The final meeting of the month was held on June 24, with Chairman Ludwig presiding. At the conclusion of the business portion, which included the nomination of officers for the next term, another Boeing film, *BAC 502 Gas Turbine*, was shown.

California State Polytechnic College

V. Keith Putnam

Outgoing Chairman

The Student Branch of California State Polytechnic College held its Annual Spring Banquet on June 13. Over 60 members and guests were present.

The honored guests were: E. W. Robischon, IAS Western Region Manager; Philip A. Colman, Chief Aerodynamics Engineer, Lockheed Aircraft Corporation, principal speaker of the evening; Lester W. Gustafson, Head, Aeronautics Department, Cal Poly; Harold P. Haves, Dean of Engineering, Cal Poly; and Edward P. Rogers, Professor of Economics, Cal Poly.

Immediately following the dinner, Chairman V. Keith Putnam introduced Mr. Robischon who briefly related some facts pertaining to his recent trip to Europe. Mr. Robischon just returned from Paris where he served under Dr. Theodore von Kármán as Consultant to the Advisory Group for Aeronautical Research of the North Atlantic Treaty Organization.

Mr. Gustafson then presented this year's student awards to the seniors who had presented the best talk to the student group and had attained the highest scholastic rating in 4 years at Cal Poly.

Mr. Colman presented a talk entitled "Design of Tomorrow's Transports." In establishing the problem, four requirements for transports were emphasized: (1) that it must go fast, (2) that it must go far, (3) that it must be safe, and (4) that it must make money. In discussing the problems involved, Mr. Colman made use of many interesting slides. The comparative figures of economy, range, weight, speed, etc., of the DC-3, the 1049E Constellation, the 1049E Constellation with turboprops, and tomorrow's jet transport were portrayed on slides.

With the design requirements before us, Mr. Colman then showed a slide of a possible solution to the jet-transport problem. This design embodied radically swept wings (which allowed greater wing structural strength at high speeds), a conventional empennage configuration, and jet engines mounted close to the fuselage in the lower portion of the wing. Jet exhaust was placed behind the passengers for lower noise levels in the airplane. It was noted that greater visibility would be afforded the passengers by the wing placement nearer the tail than is conventional.

The meeting was closed by the presentation of the officers who were elected to head this IAS Student Branch next year. Accordingly, the following students were introduced: Chairman, Robert Garrison; Vice-Chairman, Gene Neil; Secretary, Jack Gresham; Corresponding Secretary, Daniel Hickey; and Treasurer, Howard Westfall.

The dinner was adjourned by Chairman Putnam at 10:30 p.m.

University of Colorado

Franz Nawrocki, *Secretary*

A meeting of the University of Colorado Student Branch was held on May 5 for the purpose of electing officers for the 1953–1954 school year. The results are as follows: Chairman, James Polosky; Vice-Chairman, Ivan Harris; Secretary, Robery Lacy; and Treasurer, Leif Lomo. Twenty-eight student members were present at the meeting.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Harper, Carl Brown, M.Sc. in Ae.E., Expert Witness & Cons. Engr., Dept. of Justice.

Morse, William, B.Sc. (Eng.), Sr. Stress Engr., A. V. Roe Canada, Ltd.

Transferred to Associate Fellow Grade

Bleakney, William M., Ph.D., Sr. Staff Physicist & Member, Advisory Council for Research & Development Labs., Hughes Aircraft Co.

Cummings, Jerry W., B.S.Ae.E., Sr. Proj. Engr., Co-Operative Wind Tunnel, California Institute of Technology.

De Haven, Hugh, Dir. of Crash Injury Research, Cornell Univ. Medical College.

Germeraad, Donald P., B.S.Ae.E., Engrg. Test Pilot, Convair (San Diego).

Poppen, John R., M.D., Cons., Douglas Aircraft Co., Inc. (El Segundo).

Puckett, Allen E., Ph.D., Head, Missile Aerodynamics Dept., Hughes Aircraft Co.

Elected to MEMBER Grade

Anderson, Kenneth G., M.S. in Ae.E., President, Research, Inc.

Arnselm, R. Harvey, Field Test Supvr., Radioplane Co.

Behrbohm, O. Hermann, Dr. rer. Nat., Aerodynamicst, SAAB.

Bloom, Charles A., B.M.E., Stress Group Leader, Canadair, Ltd.

Braham, William E., B.S. & M.E.-A.E., Ch. Engr., Zenith Plastics Co.

aircraft control systems by WESTERN GEAR

WESTERN GEAR WORKS service to the aviation industry includes the design, manufacture and testing of complete control systems for all types of aircraft.

Highly specialized knowledge gained by more than two decades of power transmission service to the aviation industry assures you of the *correct* answer in a quality product designed for complete dependability.

Other products and services include actuators, accessory drives, special gears and gear units, test equipment for laboratories, research and wind tunnels.

"GEARING FOR THE AGE OF FLIGHT"

Send for your copy of new treatise now. Please use company letterhead.

5314

WESTERN GEAR WORKS

Manufacturers of **PACIFIC-WESTERN** Gear Products

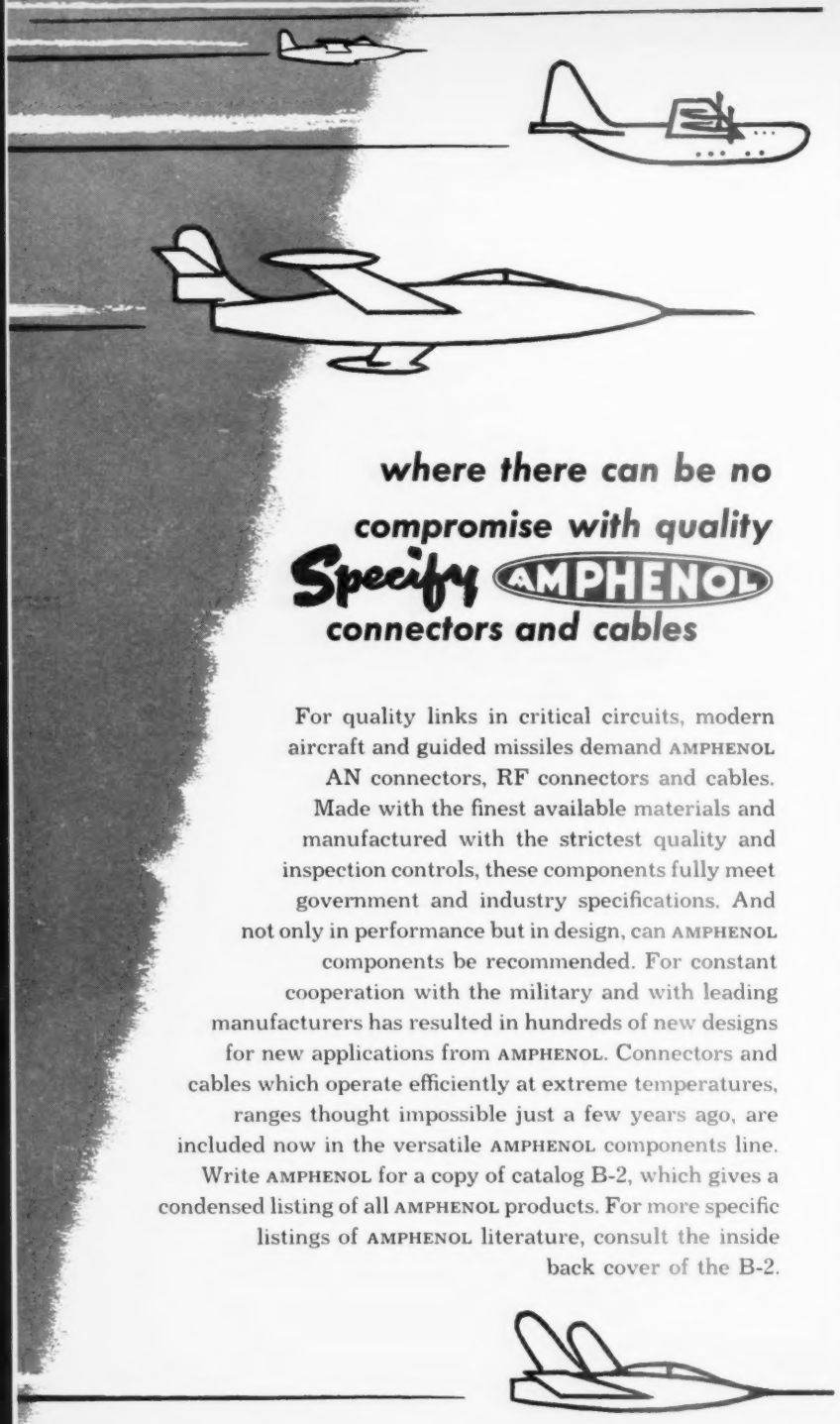
Pacific Gear & Tool Works

Our 65th year

Plants: Seattle
San Francisco
Belmont (S. F. Peninsula)
Lynwood (Los Angeles County)
Houston

Plants—417 Ninth Ave. S., Seattle 4, Washington
2600 E. Imperial Highway, Lynwood (Los Angeles County), California
1035 Folsom St., San Francisco 3, California
Belmont (San Francisco Peninsula), California
117 N. Palmer St., Houston 3, Texas

Representatives—N. 2605 Division St., Spokane, Washington
930 S. E. Oak St., Portland 14, Oregon
Room 212, Ross Bldg., Denver 2, Colorado
500 South Ervay Street, Dallas, Texas
Engineering & Machinery Ltd., 1366 W. Broadway, Vancouver, B.C.



where there can be no compromise with quality

Specify AMPHENOL connectors and cables

For quality links in critical circuits, modern aircraft and guided missiles demand AMPHENOL AN connectors, RF connectors and cables. Made with the finest available materials and manufactured with the strictest quality and inspection controls, these components fully meet government and industry specifications. And not only in performance but in design, can AMPHENOL components be recommended. For constant cooperation with the military and with leading manufacturers has resulted in hundreds of new designs for new applications from AMPHENOL. Connectors and cables which operate efficiently at extreme temperatures, ranges thought impossible just a few years ago, are included now in the versatile AMPHENOL components line. Write AMPHENOL for a copy of catalog B-2, which gives a condensed listing of all AMPHENOL products. For more specific listings of AMPHENOL literature, consult the inside back cover of the B-2.

AMPHENOL

AMERICAN PHENOLIC CORPORATION

chicago 50, illinois

Brown, Fred I., Jr., Sc.B. in M.E., Supervising Engr., Engine Design Section, Aircraft Nuclear Propulsion Project, Aircraft Gas Turbine Div., General Electric Co. (Cincinnati).

Brucker, Milton, President, Zenith Plastics Co.

Bunker, William B., M.S. in C.E., Col., Air Transport Service Div., Dept. of the Army.

Coles, Walter Wallace, B.Sc. (Hon.), Sr. Stress Analyst, de Havilland Aircraft Co. (Hatfield).

Cullen, Robert E., M.S.Ae.E., Research Assoc., Engrg. Research Institute, Univ. of Michigan.

Darr, Jack E., M.S. in E.E., Section Mgr., Westinghouse Electric Corp.

de Tavel, Franz E., M.D., Medical Adviser, ICAO (Montreal).

Dnistran, Paul, B. of Ae.E., Engr., Ramjet Devel. Section, Marquardt Aircraft Co.

Ellis, George E., B.S.M.E., Section Engr., Performance & Prelim. Design Section, J-73 Proj. Group, General Electric Co. (Evendale).

Fila, Gertrude Hill, M.S. in M.E., Instructor in Mech. Engrg., Oklahoma A. & M. College.

Fisiminger, Robert E., Jr., B.S., Sr. Aerodynamicist, Fairchild Aircraft Div., Fairchild Engine & Airplane Corp. (Hagerstown).

Griffith, Wayland C., Ph.D., Asst. Prof. of Physics, Palmer Physical Lab., Princeton Univ.

Gunther, Fred C., M.S. in A.E., Aerodynamics Research Engr., Jet Propulsion Lab., California Institute of Technology.

Hamelet, Jean H., Degrees in Naval Arch. & Aero., Sales Engr., Canadair, Ltd.

Johnson, Peter J., B.S.Ae.E., Tech. Engr., Aerodynamics Unit, Aircraft Gas Turbine Div., General Electric Co.

Jones, J. Loyd, Jr., M.S., Aero. Research Scientist (Proj. Engr.), Ames Aero. Lab., NACA.

Knap, Jozef, Aero. Tech., Group Leader, Airframe Section, Canadair, Ltd.

Ledbetter, Robert E., E.E., Engr., Advance Engine Controls, General Electric Co.

Mann, Neil W., B.S.A.E. (Engines), President, Allen Aircraft Products, Inc.

Niemela, Reino J., Field Engr., Aero Engineering, Inc.

Olson, Walter T., Ph.D., Chief, Fuels & Combustion Research Div., Lewis Flight Propulsion Lab., NACA.

Sardou, Charles, Jr., B.S. in M.E., Chief Engr., Airborne Div., G. M. Giannini & Co., Inc.

Skelton, C. H., B.Sc., District Aero. Engr., Air Services Br., Civil Aviation Div., Dept. of Transport.

Smith, Kelly G., Chief Proj. Engr., Canadair, Ltd.

Snyder, Frank L., B.S. in Engrg., Div. of Mgr., Aviation Gas Turbine Div., Westinghouse Electric Corp. (Philadelphia).

Stephens, William C., Design Engr. "A," Ryan Aero. Co.

We sharpened a long, fine drafting point on an Eagle 4H TURQUOISE pencil, snapped it off and used it as the needle in an old-fashioned phonograph.

The point held without crumbling under the weight of the arm and the vibrations of the groove, and played the full record with surprising clarity!

Here is conclusive proof that the 100% "Electronic" graphite in the TURQUOISE lead gives it a particle fineness and compactness that produce non-crumbling, amazingly wear-resisting needle points.

100% "Electronic" graphite also gives unmatched denseness and durability, with the superior smoothness, uniformity and reproduction quality every draftsman dreams of.

PROVE IT YOURSELF: Write for a sample TURQUOISE pencil in any grade you desire, and test it at your own drafting board. Please name your regular supplier and this magazine.

the Record proves that TURQUOISE holds a Needle Point

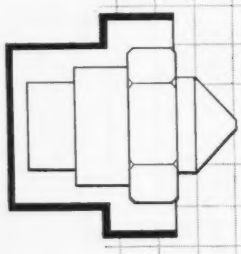
with 100% *"Electronic" Graphite

*®

EAGLE PENCIL COMPANY • NEW YORK • LONDON • TORONTO

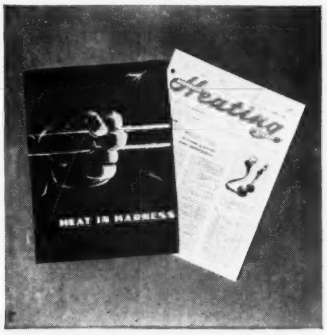
5

IF FLAMES COULD BE 'FROZEN'

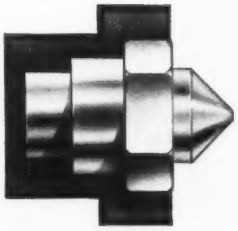


If a flame pattern could be "frozen" at simple ambient conditions, and then methodically reproduced to perform under all flight conditions—life in the combustion engineering business would be a lot simpler. The fact is, of course, that theory gives out long before the perfect picture has been drawn.

And so . . . to achieve higher-than-ever combustion efficiency . . . to locate electrodes in just the right place for positive ignition . . . to develop new tricks (like sweat cooling) for elimination of hot spots . . . to produce controlled turbulence . . . to cut down resonance . . . in short, to get flame to conform to plan is a basic objective we reach through use of the large fund of flame facts we've built over the years. If you face any of these combustion problems, your Janitrol representative can quickly show how our facilities may fit into your program.

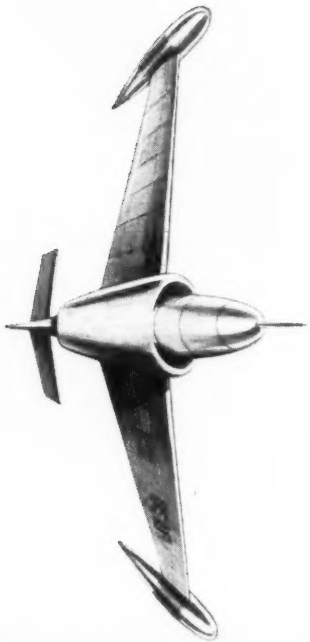


Speaking of freezing, an article on a mysterious case of ice formation on fuel nozzles in combustion heaters—and how our engineers tracked down the cause — appears in the Janitrol Heating Digest, Vol. III, No. 3. Another Janitrol publication, "Heat in Harness," gives a broad view of how several Surface Combustion Corp. Divisions work together in the advancement of combustion engineering.
Copies of either, or both, are available on request, on your letterhead, please.



Janitrol®

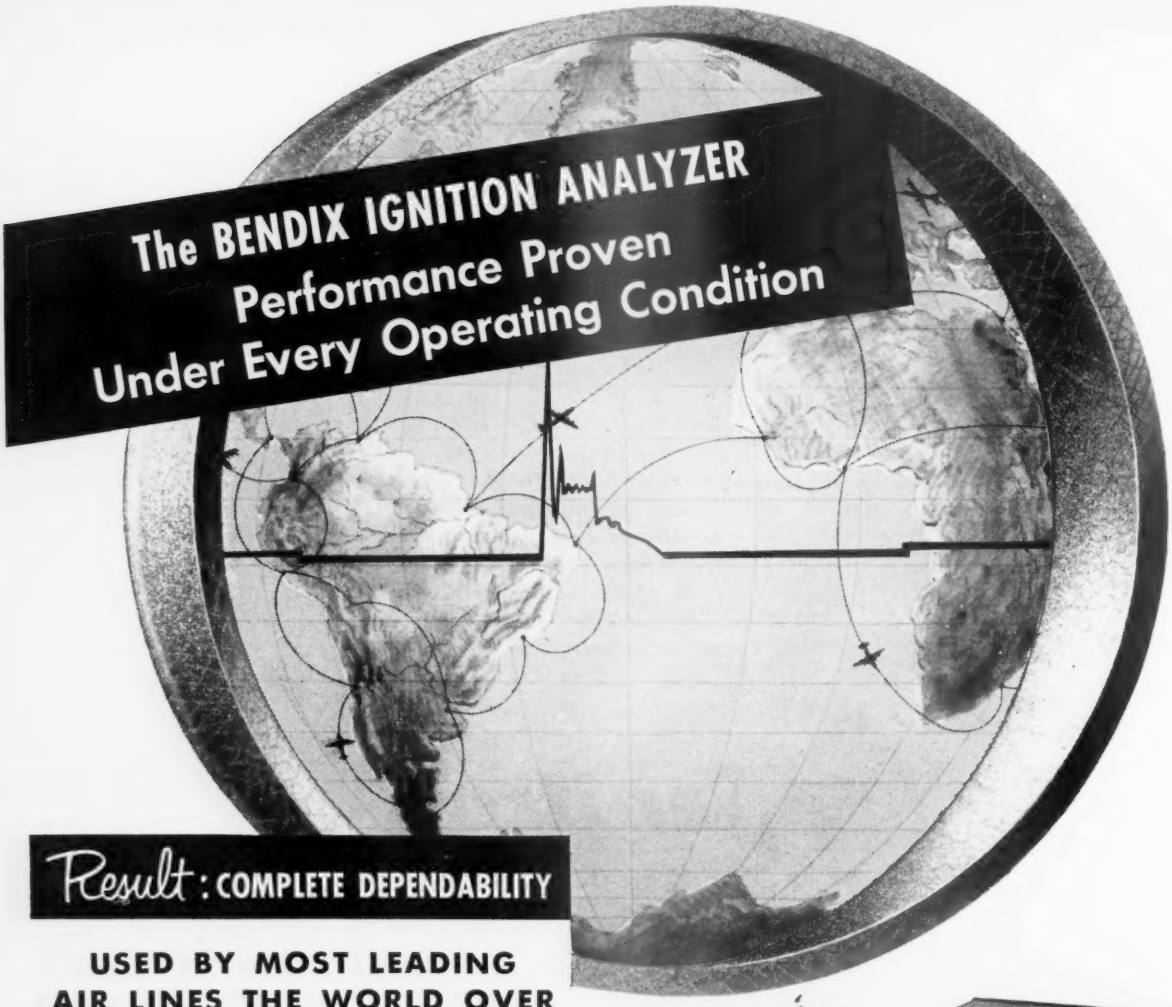
36 years experience in combustion engineering



National Sales, Engineering, Production Headquarters,
400 Dublin Avenue, Columbus 16, Ohio
District Engineering Offices:
New York, 225 Broadway
Washington, D. C., 4650 East-West Highway
Kansas City, 2201 Grand Avenue
Ft. Worth, 2509 West Berry Street
Hollywood, California, 7046 Hollywood Boulevard
Columbus, Ohio, 400 Dublin Avenue
Executive Offices:
2375 Dorr Street, Toledo 1, Ohio

AIRCRAFT-AUTOMOTIVE DIVISION, SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

KNOWN THE WORLD 'ROUND



Result: COMPLETE DEPENDABILITY

USED BY MOST LEADING AIR LINES THE WORLD OVER

Around the globe and around the clock, air-line operators have come to depend on the Bendix Ignition Analyzer as the guardian of their ignition systems.

The unfailing ability of the Bendix Ignition Analyzer to actually *foresee the future* by predicting the remaining life of individual spark plugs and by checking in advance the efficiency of all ignition units has paid handsome dividends in reduced maintenance expense, better operating schedules and increasing safety.

In every part of the world, under all types of flight conditions, the dependability and efficiency of the Bendix Ignition Analyzer have been so conclusively demonstrated that the list of its users is truly a "Who's Who" of world aviation.

In fact, you will find there is no better investment in maximum safety and operating efficiency than a Bendix Ignition Analyzer for all your aircraft operations.

Detailing literature is available on request.

Costs Less—Does More

The Bendix Ignition Analyzer is available for either airborne or portable-airborne installations. It can be used with either high or low tension magneto or battery ignition. It is the ignition analyzer that can predict spark plug failure before it occurs . . . make an efficient check of more than one spark plug at a time and do so on a large, easy-to-read screen . . . yet it costs less than comparable analyzers.

Bendix

SCINTILLA MAGNETO DIVISION OF
SIDNEY, NEW YORK

Bendix AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

FACTORY BRANCH OFFICES: 117 E. Providencia Avenue, Burbank, California • Stephenson Building, 6560 Cass Avenue, Detroit 2, Michigan
Brouwer Building, 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • 582 Market Street, San Francisco 4, California

Surwillo, Phyllis L., Design Engr., Airplane Engrg. Div., McDonnell Aircraft Corp.

Walker, James H., B.S., Asst. Group Supvr., Applied Physics Lab., The Johns Hopkins Univ.

Wilson, James H., B. of Engrg. in Aero., Design Engr., Commonwealth Aircraft Corp. Pty, Ltd.

Wirth, Fay A., Jr., B.S.E.E., Flight Test Engr., Convair (Ft. Worth).

Wright, Kenneth E., M.S. in Industrial Engrg., Comdr., USN; Naval Aviator, Dept. of the Navy (Wash., D.C.).

Transferred to MEMBER Grade

Barnes, William H., B.E. in Ae.E., Grad. Student in Aero. Engrg. (Structures), Purdue Univ.

Brenner, Harry S., M.Ae.E., Stand. Engr., Bur. of Aero., Dept. of the Navy (Washington, D. C.).

Gompf, George E., A.E., Assoc. Engr., Aircraft Div., The RAND Corp.

Hoeflein, Robert W., B.S. in Ae.E., Tech. Engr., Product Planning Group, Aircraft Gas Turbine Div., General Electric Co. (Evendale).

Johnson, Harold T., B.S. in M.E., Sr. Struct. Engr., Convair (Ft. Worth).

Lane, Frank, M.S., Research Asst., Aeronautics Dept., New York Univ.

La Vallee, Ralph S., B.S. in Ae.E., Group Leader, Aircraft Operations Section, Aircraft Div., The RAND Corp.

Lubin, Allan L., B.S.Ae.E., Design Engr.—Stress, McDonnell Aircraft Corp.

Morris, Deane N., B.S. in M.E. (AE), Head, Analysis Devel. Group, Aerodynamics Dept., Bell Aircraft Corp.

Pliske, Daniel R., B.S.A.E., Wind Tunnel Tests Rep.—Research Labs., Aerodynamics Dept., McDonnell Aircraft Corp.

Renalds, Otis B., M. of Ae.E., Flight Test Engr.—Instrumentation, Lockheed Aircraft Corp.

Rolfe, Rial E., Jr., B. of Ae.E., Airplane Loads Engr., McDonnell Aircraft Corp.

Turnbull, Norman L., B.Sc. in Ae.E., Test Engr., Pratt & Whitney Aircraft Div., United Aircraft Corp.

Elected to Associate Member Grade

Cavanagh, George, Lead Planner, Canadair, Ltd.

Clifford, Robert J., Inspector, Aircraft & Ord. Products, Comdr. of Air Sea Rescue Boat, USN, Air National Guard.

Riordan, William F. J., B.S. in E.E., M.A. in Psych., Sales Administrator, Lockheed Aircraft Corp.

Salkin, Lester H., B.S.Ae.E., Production Co-Ordinator, Christian E. Burckel & Associates.

Stewart, Fred M., Mgr., Aviation Dept., Shell Oil Co. (Los Angeles Div.).

Warzyn, Howard H., Sr. Engr., Industrial Dept., National Safety Council.

Elected to Technical Member Grade

Barnes, K. M., Proj. Engr., Hardman Tool & Engrg. Co.

Chumley, Charles L., Jr., B.S. in Chemistry & B.S. in Physics, Service Liaison Engr., Fairchild Aircraft (Hagerstown).

Connor, Donald, B.S.M.E., Project Engr., Flight Control Unit, All Weather Section, WADC, USAF, Wright-Patterson AFB.

Griffith, Billy J., B.S., Aerodynamics Engr., Convair (Ft. Worth).

Hardie, Daniel B., B.S., Asst. Research Aerodynamicist-Proj. Leader, Wind Tunnel Dept., Cornell Aeronautical Lab., Inc.,

Hilker, William R., B.S. in Engrg., Stress Analyst "A," Northrop Aircraft, Inc.

Kam, Clifford Y. K., M.S., Assoc. Engr., Struct. Group, Douglas Aircraft Co., Inc. (Santa Monica).

Reid, John W., Field Service Rep., A. V. Roe Canada, Ltd.

Sato, Hiroshi, B. of Engrg., Research Asst., Polytechnic Institute of Brooklyn.

Steinbacher, Robert H., B.S., Proj. Engr., Jet Propulsion Lab., California Institute of Technology.

Werner, Henry J., B.Sc., Design & Layout Engr., Chase Aircraft Co., Inc.

Werner, Norbert M., B.S.M.E., Aerodynamics Engr., Convair (San Diego).

White, Gerald B., M.S. in Ae.E., Mech. Research Engr., Midwest Research Institute.

Transferred to Technical Member Grade

Albers, William P., B.S., Ens. USN; Naval Officer, U. S. Naval Academy.

Allen, Lee T., Grad. Student, Georgia Institute of Tech.

Anderson, Lester J., Jr., B.S. in Ae.E., Engrg. Draftsman "A," Proj. Group, North American Aviation, Inc. (Columbus).

Augustine, Francis E., B. of Ae.E., Naval Officers Candidate School, USNR.

Bernhard, David L., B.S., Prelim. Design Engr., Cessna Aircraft Corp.

Bohning, Donald C., B.S.A.E.

Brinker, Robert C., B.S. in Ae.E., 2nd Lt., USAF.

Brun, Robert F., B.S. in Ae.E., Aerodynamicist, North American Aviation, Inc. (Downey).

Chou, Kuan-Chun, Ph.D. in Ae.E., Engr.—Design, Office of Hardesty & Hanover Cons. Engrs.

Clements, Harry R., B.S., Aerodynamicist, Commercial Div., Cessna Aircraft Co.

Deex, Arthur J., B.S. in E.E., Lt. & Pilot, USAF.

Di Cristina, Victor S., B.M.E., Research Analyst, North American Aviation, Inc. (Downey).

Duncan, Robert C., B.S. in Ae.E., Lt., USN (Wash., D.C.).

Ellingson, Wayne A., Engrg. Draftsman "A," North American Aviation, Inc. (Downey).

Evans, George W., Jr., B.S., Liaison Engr. "B," Douglas Aircraft Co., Inc. (Tulsa).

Hansen, Robert H., B. of Ae.E., 2nd Lt., ARDC, USAF.

Harms, Jack W., B.S., Aircraft Engine Exp. Test Stand. Engr., Allison Div., General Motors Corp.

Harvey, Charles E., Jr., B.S.M.E., Jr. Design Engr.—Power Plant, Chance Vought Aircraft Div., United Aircraft Corp.

Hewitt, Victor D., B.S. (Aero.), Engrg. Draftsman "B," North American Aviation, Inc. (Columbus).

Hromas, Leslie A., M.S. in Ae.E., Grad. Student, Purdue Univ.

Kriegshauser, William A., B.S. in Ae.E., 2nd Lt., USAF, 3401 Student Sq., Keesler AFB.

Lemon, D. A., B.S. in A.E., Jr. Engr., Field Service Engrg. Dept., Sperry Gyroscope Co. Div., The Sperry Corp.

Littman, Stanley, B. of Ae.E., Performance Engr., Aircraft Gas Turbine Div., Westinghouse Electric Corp.

Matz, Roy J., B.S. in Ae.E., 2nd Lt., USAFR.

Meade, Carl B., B.S. in Ae.E., Inspection Methods Engr., Sperry Farragut Corp.

Menkes, Hans R., B.S., Research Asst., Polytechnic Institute of Brooklyn.

Miller, Richard J., B.S. in Ae.E., 2nd Lt., USAFR, Student Pilot, Graham AFB.

Pitkin, Edward T., M.S. in Ae.E., 2nd Lt., USAF, Research & Devel., Wright-Patterson AFB.

Salem, G. Melvin, B.S. in Ae.E., Jr. Engr.—Flight Test, Lockheed Aircraft Corp. (Burbank).

Schuster, Max Joseph.

Sheehan, Walter E., Flight Test Analyst, Lockheed Aircraft Corp. (Van Nuys).

Stalzer, Charles E., S.B., Grad. Student, Massachusetts Institute of Technology.

Stewart, Walter C., Jr., B.S. in Ae.E., Capt., USMC.

Thayer, Ralph E., B.S. in Ae.E., Jr. Engr.—Flight Test Analyst, Lockheed Aircraft Corp.

Throop, James Ray, B.S. (Elec. & Marine Engrg.), Ens., USN; Line Officer (U.S.S. "Wilkinson").

Vague, Melvin, B.S., Analysis Engr.—Helicopter Div., Cessna Aircraft Co.

Vannatta, Richard W., Jr., B.S.E. in Ae.E.

Veevaert, E. E., Jr. Engr., Electrical Dept., Northrop Aircraft, Inc.

Wiltse, Philip D., B.S. in Ae.E., Aerodynamicist, North American Aviation, Inc. (Downey).

DOW

MAGNESIUM CUTS DEAD WEIGHT, INCREASES HELICOPTER EFFICIENCY

Extensive use of DOW MAGNESIUM sheet, extrusions, and sand castings saves many important pounds on this versatile aircraft

When you have to go straight up from a standing start, weight saving is of prime importance. That's why designers of helicopters are making extensive use of magnesium, the world's lightest structural metal.

The range and capacity of one current production model helicopter have been greatly increased by the use of magnesium. In this ship the requirements of magnesium are equal to approximately 25% of the craft's total empty weight. This consists of 400 pounds of castings, comprising 90 different parts, and 700 pounds of sheet and extrusions, including nearly all of the fuselage skin.

The weight saved by the use of magnesium has helped increase the efficiency of helicopters. Where only yesterday these craft were novelties, today they are the real work horses of our armed forces.

Whenever you have a weight problem, investigate magnesium. One-third lighter than aluminum, magnesium offers you an exceptionally high strength/weight ratio. It is a practical metal, available in all common forms, workable by all standard shop methods. For complete information, call your nearest Dow office or write to: Magnesium Department, THE DOW CHEMICAL COMPANY, Midland, Michigan.

you can depend on DOW MAGNESIUM

DOW

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

Aerodynamics 88
Boundary Layer & Thermoaerodynamics 88
Control Surfaces 88
Fluid Mechanics & Aerodynamic Theory 88
Internal Flow 92
Stability & Control 92
Wings & Airfoils 92
Aeroelasticity 96
Air Transportation 96
Airplane Design 96
Airports 96
Aviation Medicine 96
Computers 98
Education & Training 100
Electronics 100
Antennas 102
Circuits & Components 102
Electronic Controls 107
Electronic Tubes 108
Measurements & Testing 108
Navigation Aids 110
Transmission Lines 110
Wave Propagation 110
Equipment 110
Hydraulic & Pneumatic 112
Flight Operating Problems 112
Ice Prevention & Removal 112
Flight Safety & Rescue 112
Fires 112
Flight Testing 114
Fuels & Lubricants 114
Gliders 116
Instruments 116
Pressure-Measuring Devices 116
Machine Elements 117
Materials 117
Corrosion & Protective Coatings 117
Metals & Alloys 118
Metals & Alloys, Ferrous 118
Metals & Alloys, Nonferrous 118
Nonmetallic Materials 118
Testing 120
Mathematics 120
Meteorology 120
Military Aviation 120
Missiles 120
Ordnance & Armament 120
Photography 122
Physics 122
Power Plants 122
Production 124
Metalworking 124
Propellers 124
Reference Works 124
Rotating-Wing Aircraft 124
Stability & Control 124
Space Travel 124
Structures 124
Bars & Rods 124
Beams & Columns 126
Cylinders & Shells 126
Elasticity & Plasticity 126
Plates 126
Thermodynamics 127
Combustion 127
Heat Transfer 127
Water-Borne Aircraft 128
Wind Tunnels & Research Facilities 128

II. BOOKS REVIEWED IN THIS ISSUE

Book Notes 131

Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada. Members of The Paul Kollsman Lending Library who are not Members of the Institute may borrow books and, in special cases, other research material. Members of the IAS may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

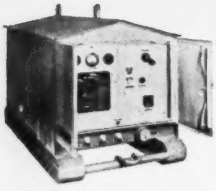
Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.35 to members and Corporate Members ($0.45 to nonmembers) for each 8½- by 11-in. print and $0.40 to members and Corporate Members ($0.50 to nonmembers) for each 11½- by 14-in. print, plus postage. A minimum charge of $1.00 is made to nonmembers of the IAS.

Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $12 to $14 per 1,000 words, depending on the language. IAS members receive a 20 per cent discount on bibliographies and translations.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N.Y.

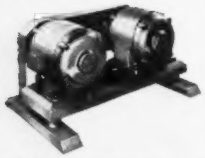
"packaged"
high frequency
power
supplies
for ground
installations

American Electric supplies these complete, "*packaged unit*" power supplies for *all* high frequency requirements. Noted for their rugged, reliable performance, the amazingly low maintenance factor of American Electric alternators results from a unique and exclusive design principle: *a rotating inductor without coils; without springs, slip rings or brushes!* Nothing to wear out, nothing to service . . . *as maintenance-free as its two sealed ball bearings!*

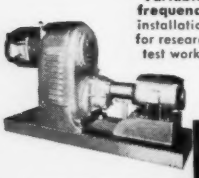


Semi-portable, skid-mounted missile launching power supply completely weather protected.

Portable, caster-mounted 400 cycle installation for production test equipment.



Stationary installation, vee belt drive, resilient mounted for laboratory h.f. test equipment.



Variable frequency installation for research test work.

Manufacturers Also of Miniature A.C. (All Frequencies) Electric Drive Motors, Blowers and Fans

Correct Power Supply for Every Installation

Portable, semi-portable or stationary types, open models or completely enclosed for weather protection. Caster or pneumatic tire mounts, skid mounts and resilient rubber mounts on stationary types.

Wide Frequency Ranges

Fixed Frequencies from 250 cycles to 2400 cycles (up to 4000 cycles in the lower ratings).

Variable Frequencies from 380 cycles to 1200 cycles and 1200 cycles to 2400 cycles.

Excellent Voltage Regulation: Standard ± 1% to as low as ± .5% depending upon choice of drive. Electronic regulators or magnetic amplifier regulators supplied.

Motor Drives—Common shaft, direct connected, Vee belt or positive, no-slip timing belt types. Variable speed on variable frequency models.

Low Harmonic Content
Less than 2% on single phase.
Less than 1% on three phase.
Exceedingly low harmonic content results directly from alternator design without use of filters.

Output Ranges
single phase—500 watts to 15 KVA
three phase—500 watts to 30 KVA
(outputs up to 75 KVA available in other alternator designs.)

WHATEVER YOUR GROUND POWER SUPPLY REQUIREMENTS
Ask American Electric for quotation

NOW! Ask for Details!
American Electric Auxiliary Airborne
MISSILE POWER SUPPLIES

AMERICAN ELECTRIC MOTORS
TRADE MARK

6911 Telegraph Road,
Los Angeles 22,
California

Engineering Representatives: TRAVCO ENGINEERING CO.
SILVER SPRING (MD.), CHICAGO, NEW YORK, LOS ANGELES

Aerodynamics

A Comparison of Calculated and Measured Base Pressures of Cylindrically Based Projectiles. Appendix — Calculation of Reynolds Number Effect on Projectiles at Supersonic Speeds. W. F. Cope. *Gt. Brit., ARC CP 118* (May 30, 1952; July, 1946), 1953. 12 pp. BIS, New York. $0.55.

Boundary Layer and Thermoaerodynamics

Calcul de la Couche-Limite Laminaire Compressible; Méthode Rapide Applicable au Cas de la Plaque Plane (Calculation of the Compressible Laminar Boundary-Layer; Rapid Method Applicable to the Case of a Flat Plate). F. Bouniol and E. A. Eichelbrenner. *La Recherche Aéronautique*, July-Aug., 1952, p. 17. In French. Theoretical conditions provide that the gas be governed by the law of Sutherland and that the Prandtl Number remain constant; possibility of extending the procedure to the general case where the exterior pressure is variable.

The Numerical Solution of Certain Differential Equations Occurring in Crocco's Theory of the Laminar Boundary Layer. S. Kirkby and T. Nonweiler. *Coll. of Aeronautics, Cranfield, Rep. 74*, May, 1953. 9 pp.

On Reflection of Shock Waves from Boundary Layers. H. W. Liepmann, A. Roshko, and S. Dhawan. (*U.S., NACA TN 2334*, 1951.) *U.S., NACA Rep. 1100*, 1952. 29 pp. 20 refs. Supt. of Doc., Wash. $0.30.

Three-Dimensional Laminar Boundary-Layer Flow. Franklin K. Moore. *J. Aero. Sci.*, Aug., 1953, p. 525. Possibilities for predicting steady three-dimensional behavior from the case of a cone at angle of attack to a supersonic stream.

Control Surfaces

Calcul par la Théorie des Écoulements Supersoniques Linéarisés des Moments de Charnière de Gouvernes Équipant une Aile Rectangulaire. Claude Picard. *La Recherche Aéronautique*, July-Aug., 1952, p. 3. In French. Calculation, utilizing the theory of linear supersonic flow, of the moments of rudder-control surfaces fixed on a rectangular wing.

The Effect of Curvature of Surface and Thickness of Trailing Edge on Aileron Hinge Moments. I—Modification to Aileron on Upper Surface. A. S. Batson, C. H. Burge, and J. R. Greening. **II—Modification to Aileron on Lower Surface. III—Modification to Aileron on Both Surfaces.** A. S. Batson, C. H. Burge and W. C. Skelton. *Gt. Brit., ARC R&M 2506* (Oct. 20, 1942), 1953. 48 pp. BIS, New York. $2.85.

Fluid Mechanics & Aerodynamic Theory

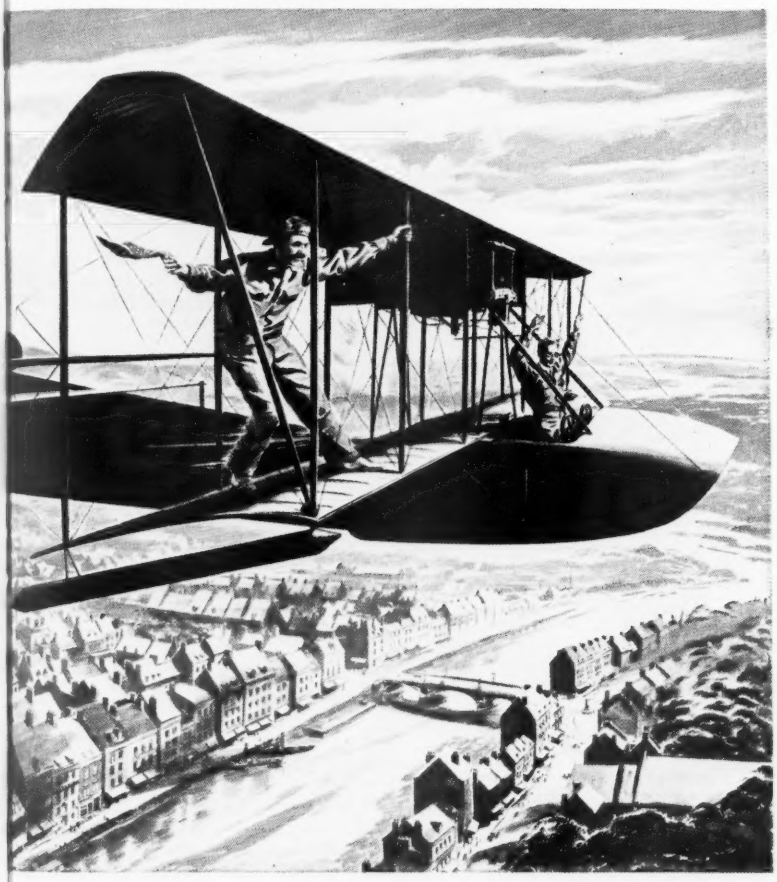
Calcul d'une Tuyère et d'un Profil dans l'Approximation "Homographique." A. Gilles. *La Recherche Aéronautique*, Mar.-Apr., 1953, p. 3. In French. Calculation of flow problems involved in the construction of a nozzle and a transonic symmetric body by the linear ("homographie") approximation:

$$(a_0\sigma + 1)\,\mathrm{tg}\,u - u = \pm a_0\theta$$

1912 Lawrence Sperry, at 19, flew automatically with the first Sperry Stabilizer. In 1914, Sperry won award offered by the French War Department for the first "stable airplane."

AUTOMATIC FLIGHT...

another Sperry first... 1912



From the day in June, 1914, when Lawrence Sperry won the French War Department's 50,000 franc prize for the first "stable airplane," Sperry has taken the lead in making flying more and more automatic . . . as flying itself has required more and more precision. From the first simple stabilizer have come development after development, such as the Sperry Automatic Pilot and Automatic Approach Control to guide planes to better landings under all weather conditions.

TODAY, AS ALWAYS, SPERRY LEADS THE WAY

In production today at Sperry are instruments that give man even greater mastery of the elements. And the military demand is so great that hundreds of subcontractors are now sharing with Sperry the important task of meeting these requirements.

1953 USAF's Boeing B-47B is equipped with Sperry Gyropilot, combining the latest in gyroscopic, servo, and signal system techniques.

1933 Wiley Post in the Winnie Mae made first solo, round-the-world flight. Using the Sperry Automatic Pilot, Post was able to nap while plane, under automatic control, flew itself.

1946 United Air Lines installed Sperry A-12 Gyropilot on four-engine fleet to insure precise automatic instrument approaches to airport runway.

19?? Sperry laboratories are busy today solving automatic control problems for jets and missiles of the future to control them with precision.

SPERRY GYROSCOPE COMPANY
DIVISION OF THE SPERRY CORPORATION
GREAT NECK, NEW YORK

PROGRESS 50TH ANNIVERSARY OF POWERED FLIGHT SECURITY

One of a Series of Advertisements Commemorating the 50th Anniversary of Powered Flight.

TECH·FORGE *flexible* BELLOWS

add strength...save weight!

For maximum flexibility and fatigue resistance—plus light weight —specify Standard-Thomson *Tech-Forge* Bellows. In fabrication, the exclusive Tech-Forge process minimizes thinning of the metal. Thus extra-flexible, light-gauge alloys can be used to advantage, without loss of strength. Tech-Forge stainless steel bellows are regularly furnished in sizes from ¾″ to 36″ I.D. and alloys suited for use in exhaust, cabin heating, de-icing and other systems. For full engineering details, write:

STANDARD-THOMSON CORPORATION · DAYTON 2, OHIO

Standard-Thomson

Makers of USAF-approved bellows • valves • lights

Shut-off Valves | Barometric Pressure Valves | Cockpit Lamp Assembly | Vaporproof Cabin Lamp

An Experimental Study of Standing Waves. Geoffrey Taylor. *Proc. Royal Soc. (London), Ser. A*, June 9, 1953, p. 44. Cavendish Lab. investigation to test results obtained in the Penney and Price analysis of free oscillations existing in water contained between two parallel vertical plane walls.

Heat Transfer to Bodies in a High-Speed Rarefied-Gas Stream. Jackson R. Stalder, Glen Goodwin, and Marcus O. Creager. (*U.S., NACA TN 2438*, 1951.) *U.S., NACA Rep. 1093*, 1952. 10 pp. 22 refs. Supt. of Doc., Wash. $0.15.

Investigation of the Instability of a Moving Liquid Film. H. B. Squire. *Brit. J. Appl. Phys.*, June, 1953, p. 167.

Les Mouvements Plans, non Stationnaires, à Circulation Constante; Comparaison des Résultats Théoriques et Expérimentaux. H. Werlé and Henry Girerd. *La Recherche Aéronautique*, Mar.-Apr., 1952, p. 13. In French. Saint-Cyr hydrodynamic tunnel investigation of nonstationary plane motion at constant circulation.

Oblique Water Entry of a Wedge. P. R. Garabedian. *Commun. on Pure & Appl. Math.*, May, 1953, p. 157. A mathematical analysis of the surface-flow problem.

Studies on Wake Vortices. I—An Experimental Study on the Structure of the Vortex Street Behind a Circular Cylinder of Finite Length. Sadatoshi Taneda. *Kyushu U., Japan, Rep. Res. Inst. Appl. Mech.*, Dec., 1952, p. 131.

Sur l'Entretien des Oscillations des Eaux Portuaires sous l'Action de la Haute Mer. John S. Mc Nown. *France, Min. de l'Air PST 278*, 1953. 45 pp. 16 refs. In French. Experimental research on fundamental characteristics of wave oscillations in port excited by surging seas; analysis of resonant and nonresonant movements; applications.

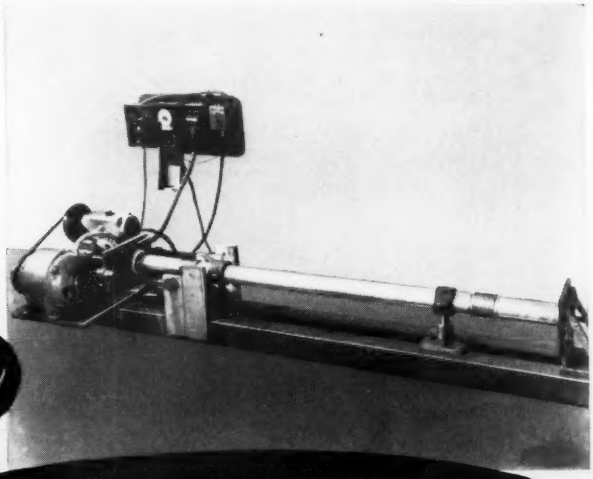
Unsteady Radial Flow of Gas Through Porous Media. R. Jenkins and J. S. Aronofsky. *J. Appl. Mech.*, June, 1953, p. 210.

The Use of Influence Factors in Problems of Fluid Flow. K. H. V. Britten. *Gt. Brit., ARC R&M 2441* (Apr., 1947), 1952. 13 pp. BIS, New York. $1.00.

Determination of the Drag on a Cylinder at Low Reynolds Numbers. R. K. Finn. *J. Appl. Phys.*, June, 1953, p. 771. Measurements at Reynolds Numbers from 0.06 to 6.0.

Drag of Circular Cylinders for a Wide Range of Reynolds Numbers and Mach Numbers. Forrest E. Gowen and Edward W. Perkins. *U.S., NACA TN 2960*, June, 1953. 26 pp. 15 refs.

Existence des Mouvements Plans non Stationnaires d'un Profil à Pointe dans Lesquels les Forces Aérodynamiques ne Travaillent Jamais. G. Couchet. *La Recherche Aéronautique*, July-Aug., 1952, p. 13. In French. Existence of plane nonstationary motion of a pointed body, where aerodynamic forces are never operative, with constant circulation characteristic of simple kinematic conditions that are used to treat of a relationship to the problem of control.



15 hour fatigue test on RF-40 at ±2° radial motion, frequency 60 cycles/min. Assembly at 200 psi, 580° F.

Rigid laboratory tests like these prove the ability of FLEXONICS FLEXIBLE METAL AIRCRAFT COMPONENTS to withstand flight conditions

250 hour fatigue test on hose at 133 cycles/sec. using .006" peak-to-peak amplitude.

A valuable plus is yours when you specify Flexonics stainless steel flexible metal hose, bellows, ducting or flexible connectors. The design of every Flexonics assembly is checked, double checked and proved in extensive modern laboratories before it goes into the aircraft. In the Flexonics labs special testing machines simulate actual flight conditions of heat, cold, vibration and flexation . . . safely prove the unit on the ground with-out endangering valuable lives and equipment aloft. Coupled with Flexonics Corporation's unmatched manufacturing experience, the laboratory-proved ability of Flexonics assemblies to take it is another good reason for specifying "Flexonics" for all flexible stainless steel components.

Your Flexonics representative will be pleased to go over your requirements with you.

Flexonics *Corporation*

AIRCRAFT DIVISION
1309 S. THIRD AVENUE • MAYWOOD, ILLINOIS

FORMERLY CHICAGO METAL HOSE CORPORATION
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

Flexon identifies products of Flexonics Corporation that have served industry for over 50 years.

Flexible metal hose

Expansion joints

Aircraft components

Metallic bellows

Growth of Boundary Layer on a Rotating Sphere. Dayal Nigam and Srinivasa Iyengar Rangasami. *ZAMP*, May 15, 1953, p. 221. The problem of the growth of fluid motion in initial stages of development.

Impulsive Motion of a Flat Plate. John W. Miles. *Quart. J. Mech. & Appl. Math.*, June, 1953, p. 129. Analysis of the transient motion of a flat rectilinear plate in a compressible fluid.

On the Slow Motion of an Ellipsoid in a Rotating Fluid. I—A Formal Solution. II—Uniform Motion. K. Stewartson. *Quart. J. Mech. & Appl. Math.*, June, 1953, p. 141.

Steady Motion Around a Symmetrical Obstacle Moving Along the Axis of a Rotating Liquid. Robert R. Long. *J. Meteorology*, June, 1953, p. 197. 19 refs. Extension of G. I. Taylor's theory and investigations.

Supersonic Flow About Slender Bodies of Elliptic Cross Section. A. Kahane and A. Solarski. *J. Aero. Sci.*, Aug., 1953, p. 513. Application of the generalized Ward theory to the zero-angle-of-attack pressure distribution on elliptic cones and parabolic arc bodies.

Supersonic Flow over Conical Bodies Without Axial Symmetry. Antonio Ferri, Nathan Ness, and Thaddeus T. Kaplita. *J. Aero. Sci.*, Aug., 1953, p. 563. Analysis by the superposition of linear conical solutions to the nonlinear problem of flow fields around conical bodies of elliptical, drop-shape, and triangular cross section for a wide range of Mach Numbers.

Sur la Force Vive d'un Fluide et le Calcul des Efforts de ce Fluid sur un Profil en Mouvement. G. Couchet. *La Recherche Aéronautique*, Mar.-Apr., 1953, p. 11. In French. Calculation of non-turbulent aerodynamic forces on a movable body in incompressible flow in a perfect fluid at constant circulation from rest to infinity.

A Method for Stabilizing Shock Waves in Channel Flow by Means of a Surge Chamber. Stanford E. Neice. *U.S., NACA TN 2694*, June, 1953, 46 pp.

Analyse Strioscopique d'Écoulements Supersoniques à Trois Dimensions. Claude Picard. *La Recherche Aéronautique*, Mar.-Apr., 1953, p. 15. In French. Strioscopic analysis of three-dimensional supersonic flow problems permitting study of attached or detached waves in front of wings, fuselage, and tail assembly, with or without sweep.

Su un Metodo Pratico e Rapido di Soluzione Grafica dei Problemi di Aerodinamica Supersonica in Due Dimensioni (On a Quick and Rapid Method for the Graphical Solution of Bidimensional Supersonic Problems). D. Cunsolo. *L'Aerotecnica*, Apr., 1953, p. 166. In Italian. A method utilizing simplified tables to furnish the direction of Mach Waves.

The Microstructure of Turbulent Flow. A. M. Obukhoff and A. M. Yaglom. (*Prikladnaya Matematika i Mekhanika*, 1951, p. 3.) *U.S., NACA TM 1350*, June, 1953. 41 pp. 25 refs. Translation. Quantitative description of the structure of the fundamental hydrodynamic fields for the entire range of Kolmogoroff's general theory of locally isotropic turbulence.

Internal Flow

Efficiency and Drag of an Axial-Flow Compressor Stage; The Connexion Between the Efficiency of a Stage, the Forces on the Blade Sections and the Profile Drag; The Relation Between Different Definitions of Efficiency, and the Effect of Other Sources of Loss. J. M. Stephenson. *Aircraft Eng.*, June, 1953, p. 158.

The Expression for Work in a Root's Blower. J. Kestin and J. A. Owczarek. *IME Proc. (B), Appl. Mech.*, No. 3, 1952, p. 91; Communications, p. 95. Analysis of the compression mode in a Root's air compressor; derivation of a refined formula for the isentropic process and the pressure equalization system.

Observations of Propagating Stall in Axial-Flow Compressors. Toru Iura and W. Duncan Rannie. *CIT Mech. Eng. Lab. Rep. 4*, Apr., 1953. 57 pp.

Subsonic Flow of Air Through a Single-Stage and a Seven-Stage Compressor. Chung-Hua Wu. *U.S., NACA TN 2961*, June, 1953. 32 pp. 12 refs.

Beitrag zur Kenntnis der Eigenschwingung einer idealen Flüssigkeit in kommunizierenden Röhren. Hsien-Chih Liu. *ZAMP*, May 15, 1953, p. 185. In German. Analytical investigation of oscillation of an ideal liquid in communication tubes of arbitrary shape leading to the derivation of a nonlinear differential equation of the second order.

Influence of Viscous Effects on Impact Tubes. C. W. Hurd, K. P. Chesky, and A. H. Shapiro. *J. Appl. Mech.*, June, 1953, p. 253.

On the Flow in a High-Pressure Valve. F. A. Goldsworthy. *Proc. Royal Soc. (London), Ser. A*, June 9, 1953, p. 69. Development of an approximate theory of the motion of air in a valve while it is opening related to the outflow of air from a high-pressure chamber along a tube.

The Structure of Turbulence in Fully Developed Pipe Flow. John Laufer. *U.S., NACA TN 2954*, June, 1953. 53 pp. 18 refs.

Les Autoplissements et les Équations Intrinsèques des Fluides Visqueux. François-Joseph Bourrières. *France, Min. de l'Air PST 279*, 1953. 95 pp. In French. Qualitative and quantitative experimental analysis, using liquids, of spontaneous formation and propagation of mixing of confluent jet streams at extremely low speeds under the same thermodynamic conditions; parabolic distributions of speeds of simple jets; intrinsic equations of fluid flow and viscous wave moments of isochronic curve jet lines; applications to internal wake and other problems.

Flows through Nozzles and Related Problems of Cylindrical and Spherical Waves. I—Supersonic Flows through Nozzles. II—Existence Theorems in the Characteristic Plane. Yu Why Chen. *Commun. on Pure & Appl. Math.*, May, 1953, pp. 179; 183; 209. 22 refs.

One-Dimensional High-Speed Flows; Flow Patterns Derived for the Flow of Gases Through Nozzles, Including Compressibility and Viscosity Effects. J. Kestin and S. K. Zaremba. *Aircraft Eng.*, June, 1953, p. 172. 19 refs.

Supersonic Diffusion in the Presence of a Boundary-Layer. E. L. Place and A. G. Smith. *Power Jets Memo. M.1071*, Feb., 1945. 12 pp. Tests dealing with a simple diffuser of rectangular cross-section having one divergent wall and intended to operate with a normal shock located at the entry plane, at an approach Mach Number of 1.5.

Stability & Control

Analysis of the Effects of Wing Interference on the Tail Contributions to the Rolling Derivatives. William H. Michael, Jr. (*U.S., NACA TN 2332*, 1951.) *U.S., NACA Rep. 1086*, 1952. 12 pp. Supt. of Doc., Wash. $0.20.

(Elevator) Control Reversal. H. K. Millicer. *Aircraft* (Australia), May, 1953, p. 21. Discussion of technical problems.

Flight Investigation of the Effect of Control Centering Springs on the Apparent Spiral Stability of a Personal-Owner Airplane. John P. Campbell, Paul A. Hunter, Donald E. Hewes, and James B. Whitten. (*U.S., NACA TN 2413*, 1951.) *U.S., NACA Rep. 1092*, 1952. 17 pp. Supt. of Doc., Wash. $0.20.

Possibilités d'Assimilation d'un Engin Volant, Gouvernes Libres, à un Servo-Mécanisme. G. Coupry and R. Valid. *La Recherche Aéronautique*, Mar.-Apr., 1953, p. 29. In French. Study of linear aerodynamic coefficients in the stability problem; principles of dynamic control; application to the possibility of assimilation to a servomechanism of a flying machine freely governed.

Sulla Virata Corretta Brachistocrona (On Minimum Time Correct Turns). Gaspare Santangelo. *L'Aerotecnica*, Apr., 1953, p. 158. In Italian. Determination of the differential equation of a minimum time turn between two given directions, based on the general equation of a non-stationary correct turn, with the turning speed as a function of the traveled angle.

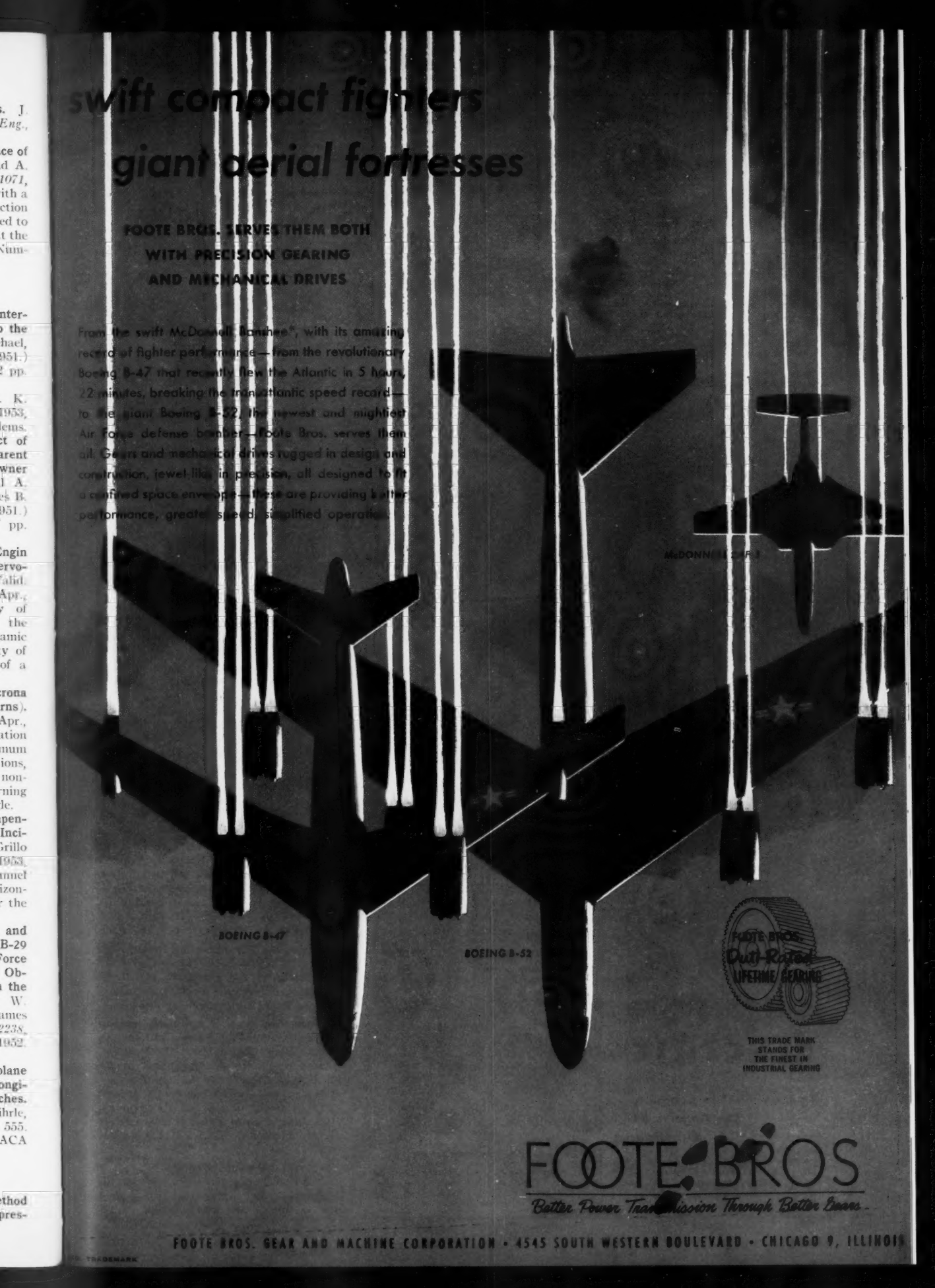
Il Calcolo dell'Incidenza dell'Impennaggio Orizzontale (A Note on the Incidence of the Stabilizer). C. Grillo Pasquarelli. *L'Aerotecnica*, Apr., 1953, p. 164. In Italian. Flight and tunnel tests to calculate the incidence of horizontal stability altered by downwash or the presence of a body or booms.

Effects on Longitudinal Stability and Control Characteristics of a Boeing B-29 Airplane of Variations in Stick-Force and Control-Rate Characteristics Obtained Through Use of a Booster in the Elevator-Control System. Charles W. Mathews, Donald B. Talmage, and James B. Whitten. (*U.S., NACA TN 2238*, 1951.) *U.S., NACA Rep. 1076*, 1952. 17 pp. Supt. of Doc., Wash. $0.20.

Studies of Some Effects of Airplane Configuration on the Response to Longitudinal Control in Landing Approaches. Ralph W. Stone, Jr., and William Bihrle, Jr. *J. Aero. Sci.*, Aug., 1953, p. 555. A theoretical investigation at the NACA Langley Aeronautical Lab.

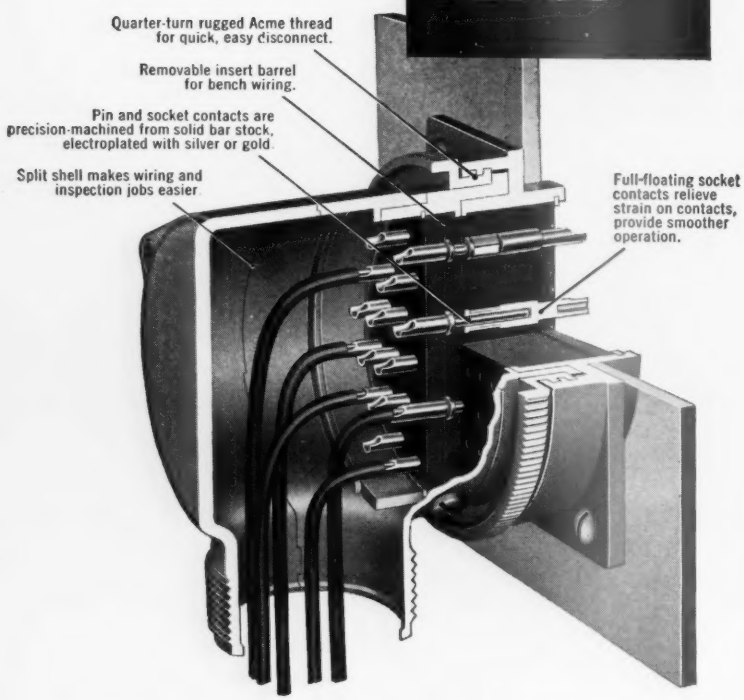
Wings & Airfoils

The Application of the Polygon Method to the Calculation of the Compres-


swift compact fighters
giant aerial fortresses
FOOTE BROS. SERVES THEM BOTH
WITH PRECISION GEARING
AND MECHANICAL DRIVES
From the swift McDonnell "Banshee", with its amazing record of fighter performance—from the revolutionary Boeing B-47 that recently flew the Atlantic in 5 hours, 22 minutes, breaking the trans-Atlantic speed record—to the giant Boeing B-52, the newest and mightiest Air Force defense bomber—Foote Bros. serves them all. Gears and mechanical drives rugged in design and construction, jewel-like in precision, all designed to fit a confined space envelope—these are providing better performance, greater speed, simplified operation.
McDONNELL XF-88
BOEING B-47
BOEING B-52
FOOTE BROS. Cut-Rated LIFETIME GEARING
THIS TRADE MARK STANDS FOR THE FINEST IN INDUSTRIAL GEARING
FOOTE BROS
Better Power Transmission Through Better Gears
FOOTE BROS. GEAR AND MACHINE CORPORATION • 4545 SOUTH WESTERN BOULEVARD • CHICAGO 9, ILLINOIS
TRADEMARK

Here's why those in the know –demand

CANNON PLUGS


Quarter-turn rugged Acme thread for quick, easy disconnect.
Removable insert barrel for bench wiring.
Pin and socket contacts are precision-machined from solid bar stock, electroplated with silver or gold.
Split shell makes wiring and inspection jobs easier.
Full-floating socket contacts relieve strain on contacts, provide smoother operation.

Recognition of Cannon's 36 years of sound engineering and fine, uncompromising construction has built the demand for Cannon Plugs. Here we take an inside look at the lightweight Type "K" 90° connector, forerunner of the Army-Navy Series. More features of the "K" were incorporated into the "AN" design than any other connector.

Constantly improved over the years, Type "K" is now used for numerous applications such as aircraft, radio, television, sound, phone recorders, motion pictures, geophysical research and widely used throughout the electro-mechanical and electronic instrument fields.

The design and construction details in the Cannon "K" Series are typical of the care Cannon takes in producing more than 18,000 precision, multi-contact connectors to serve the exacting needs of industry.

We will gladly send you engineering bulletins describing each of the many basic types of Cannon Plugs if you will briefly describe your applications.

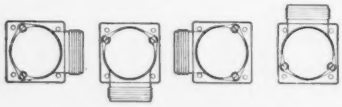


Diagram at left shows how the four positions of cable entry on the large 90° "K" endbell make the wiring job easier. Smaller Type "K" connectors have three positions.

CANNON ELECTRIC

Since 1915

Cannon Electric Company
Los Angeles 31
California

Factories in Los Angeles, Toronto, New Haven. Representatives in principal cities. Address inquiries to Cannon Electric Company, Department I-105, Los Angeles 31, California.

Type "K" and "RK" connectors are available in 7 shell types having 8 diameters. Inserts have more than 190 contact arrangements. Some of these have Coax, Twinax or Thermocouple contacts as standard. Integral cable clamps available in all "K" plug types.

sible Subsonic Flow round Two-Dimensional Profiles. L. C. Woods. *Gt. Brit., ARC CP 115* (June 27, 1952), 1953. 31 pp. BIS, New York. $1.70.

Détermination du Point de Transition et Calcul de la Trainée des Profils d'Ailes en Incompressible. R. Michel. *France, ONERA Pub. 59*, 1952. 74 pp. 32 refs. In French. Experimental methods for the exact calculation of the drag of symmetrical airfoils in incompressible flow, with an analysis of the transitional period in the boundary layer from laminar to turbulent flow.

Mesures de Pressions et d'Efforts sur une Demi-Aile Rectangulaire en Supersonique. Cl. Picard and J. P. Chevallier. *La Recherche Aéronautique*, Mar.-Apr., 1952, p. 3. In French. Study of the total forces on a supersonic rectangular wing in the vicinity of Mach Number 2 and analysis of the distribution of effective pressures.

Some Investigations on Thin Nose-Suction Aerofoils. I—A Comparison of the Stalling Properties of some Thin Nose-Suction Aerofoils. II—A Theoretical Investigation on Thin High-lift Aerofoils Specially Designed for Nose-Slot Suction. J. Williams. *Gt. Brit., ARC R&M 2693* (Apr., 1950), 1952. 28 pp. BIS, New York. $1.70.

Tables of Complete Downwash Due to a Rectangular Vortex. NPL Math. Div. Staff and V. M. Falkner. *Gt. Brit. ARC R&M 2461* (July 21, 1947), 1953. 18 pp. BIS, New York. $1.25. Application to the solution of wing-loading problems.

The Theoretical Estimation of Power Requirements for Slot-suction Aerofoils, with Numerical Results for Two Thick Griffith Type Sections. J. H. Preston, N. Gregory, and A. G. Rawcliffe. *Gt. Brit., ARC R&M 2577* (June, 1948), 1953. 27 pp. 15 refs. BIS, New York. $1.70.

The Calculation of the Profile Drag of Aerofoils and Bodies of Revolution at Supersonic Speeds. A. D. Young. *Coll. of Aeronautics, Cranfield, Rep. 73*, Apr., 1953. 30 pp. 22 refs.

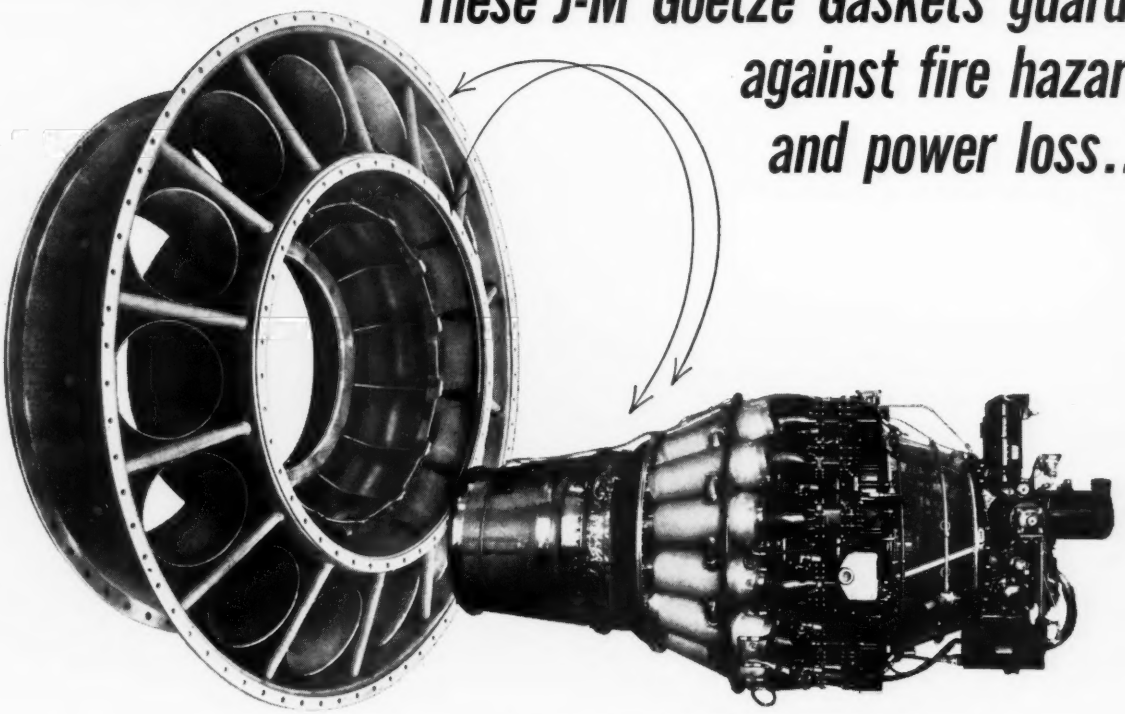
Some Effects of Streamwise Gaps on the Aerodynamic Characteristics of Low-Aspect-Ratio Lifting Surfaces at Supersonic Speeds. Z. O. Bleviss and R. A. Struble. *Douglas Rep. SM-14627*, Apr. 1, 1953. 89 pp. 17 refs.

Theorems Concerning the Drag Reduction of Wings of Fixed Planform. A. M. Rodriguez, P. A. Lagerstrom, and E. W. Graham. *Douglas Rep. SM-14445*, Mar. 20, 1953. 24 pp.

Transition and Drag Measurements on the Boulton Paul Sample of Laminar-Flow Wing Construction. I—Measurements in the 13 × 9ft Tunnel at the N.P.L. J. H. Preston and N. Gregory. **II—Measurements in the No. 2, 11½-ft Tunnel at the R.A.E.** K. W. Kimber. **III—Discussion of Results and Note by J. H. Preston.** *Gt. Brit., ARC R&M 2499* (Nov., 1946), 1952. 23 pp. 22 refs. BIS, New York. $1.50.

Zur Berechnung der Druckpunktverteilung über die Spannweite für Flügel mit kleinem Seitenverhältnis. Ernst

These J-M Goetze Gaskets guard against fire hazard and power loss...



Arrows point to J-M Goetze metallic gaskets on the inner and outer annulus, and their approximate location on the J33 turbojet engine turbine frame.

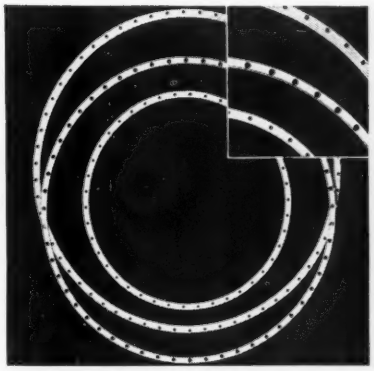
...on powerful turbojet engines like the J33

Sealing the inner and outer annulus on the J33 to prevent leakage of fuel and flame into the airframe is another example of the many tough, critical sealing jobs entrusted to Goetze custom-crafted metallic gaskets.

For this particular service condition, the Goetze gasket specified is made from a flat gasket design... with the metal on both edges rolled around an asbestos filler. This construction provides the resilience needed to overcome the warpage encountered in these applications. Like all Goetze gaskets, this style is precision-made to fit tight and stay tight in service.

There is a Johns-Manville Goetze gasket for practically every jet aircraft requirement. Goetze craftsmen can fabricate them in almost any shape or size for sealing igniters, compressor bleed-offs, cross ignition tubes, combustion chambers, fuel nozzles, turbine drain lines, etc. Backed by more than 60 years of Goetze "know-how," these durable gaskets are solving many of industry's most complex sealing problems.

Why not write for further information about Johns-Manville Goetze gaskets... and other J-M flight-proved products for the aviation industry. Ask for your copy of Brochure AV-1A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario.



Close-up of J-M Goetze metallic gaskets used as inner and outer annulus gaskets on jet engine turbine frame.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PRODUCTS for the AVIATION INDUSTRY

Schultze. *ZAMP*, May 15, 1953, p. 207. In German. Extension of the Weissinger lift-distribution theory for wings of finite span to give the spanwise distribution of the center of pressure and to calculate both lift and moment distribution.

I—Aerodynamic Forces on Biconvex Aerofoils Oscillating in a Supersonic Airstream. W. P. Jones and Sylvia W. Skan. **II—The Effect of Thickness on the Aerodynamic Forces on Biconvex Aerofoils Oscillating in a Supersonic Airstream, and Calculation of Forces for Aerofoil with Flap.** Sylvia W. Skan. *Gt. Brit., ARC R&M 2749* (Aug., 1951), 1953. 34 pp. BIS, New York. $2.00.

The Supersonic Thickness Drag of Rectangular Wings with Linear Spanwise Taper in Thickness. Kelsey Walker, Jr. *Douglas Rep. SM-14739*, Mar. 24, 1953. 22 pp.

An Approximate Method of Calculating the Subsonic Velocity Distribution on High-Aspect-Ratio Swept Wings of Small Thickness at Zero Lift. Friedrich Keune. *Stockholm, Kungliga Tekniska Högskolan, Inst. för Flygteknik, KTH-AERO* TN 26, Feb. 3, 1953. 36 pp.

Some Experiments on the Flow in the Boundary Layer of a 45° Sweptback Untapered Wing of Aspect Ratio 4. K. Emslie, L. Hosking, and W. S. D. Marshall. *Coll. of Aeronautics, Cranfield, Rep. 69*, Feb., 1953. 38 pp.

Theoretical Investigation of the Supersonic Lift and Drag of Thin, Sweptback Wings with Increased Sweep Near the Root. Doris Cohen and Morris D. Friedman, *U.S., NACA TN 2959*, June, 1953. 51 pp. 14 refs.

The Aerodynamic Characteristics of Low Aspect Ratio Wing-Body Combinations in Steady Subsonic Flow. H. R. Lawrence. *J. Aero. Sci.*, Aug. 1953, p. 541.

Drag Reduction Due to Wing Incidence and Twist for Wing-Body Combinations. Beverly Beane. *Douglas Rep. SM-14740*, Mar., 1953. 18 pp.

Surveys of the Flow Fields at the Propeller Planes of Six 40° Sweptback Wing-Fuselage-Nacelle Combinations. Vernon L. Rogallo and John L. McCloud, III. *U.S., NACA TN 2957*, June, 1953. 57 pp.

Aeroelasticity

Détermination de la Masse Généralisée à l'Aide du Procédé "Par l'Impédance." J. Rost. *La Recherche Aéronautique*, July-Aug., 1952, p. 49. In French. Experimental determination, by a new impedance procedure, of the generalized mass; calculation of the amplitude of a linear system continually excited by a resonance; applications include wing torsion and bending.

Influence de Divers Paramètres sur les Vitesses Critiques des Avions (Influence of Various Parameters on Critical Speeds of Aircraft). S. Chopin. *La Recherche Aéronautique*, Mar.-Apr., 1952, p. 41. In French. Calculations and experimental results in flutter analysis; rigidity, torsion and other aspects.

Influence of Tuned Dampers on Flexure-Aileron Flutter. I—Theoretical Investigation on the Influence of Tuned Damping Devices on Flexure-Aileron Flutter. R. A. Frazer and W. P. Jones. **II—Some Further Calculations on the Influence of Tuned Damping Devices on Flexure-Aileron Flutter.** W. P. Jones. **III—Experiments on the Effect of Tuned Damping Devices on Flexure-Aileron Flutter.** C. Scruton, D. V. Dunsdon, and P. M. Ray. *Gt. Brit., ARC R&M 2559* (20 Sept., 1946), 1952. 31 pp. BIS, New York. $1.90.

Oscillation Tests in Flight. W. Kochanowsky. (*MAP Völkenrode, AVA Monographs MAP-VG 278*, n.d.) *Gt. Brit., MOS GDC 2609T TIB Rep. & Transl. 978*, Jan. 15, 1948. 33 pp. Character of testing techniques in flutter-behavior investigations; calculations and results.

Flight Investigation of the Effect of Transient Wing Response on Wing Strains of a Four-Engine Bomber Airplane in Rough Air. Harold N. Murrow and Chester B. Payne. *U.S., NACA TN 2951*, June, 1953. 24 pp. Analysis to obtain a practical measure of wing strains and accelerations induced by gusts and amplified by transient-response effects associated with wing flexibility.

A Revised Formula for the Calculation of Gust Loads. Kermit G. Pratt. *U.S., NACA TN 2964*, June, 1953. 15 pp.

On an Iterative Method for Nonlinear Vibrations. R. E. Roberson. *J. Appl. Mech.*, June, 1953, p. 237.

On the Application of the Impedance Method to Continuous Systems. P. F. Chenea. *J. Appl. Mech.*, June, 1953, p. 233. Method applicable to the free and forced vibration of an elastic bar in longitudinal oscillation or the torsional oscillation of a tapered shaft.

Répresentation Graphique de la Résonance d'un Oscillateur Utilisable pour l'Étude de Systèmes non Linéaires. P. Liénard. *La Recherche Aéronautique*, Sept.-Oct., 1952, p. 45. In French. Graphic representation of the resonance of an oscillator for the study of nonlinear systems with viscous absorption; the influence of very small nonlinear parameters experimentally applied.

Vibration Damping. Robert Plunkett. *Appl. Mech. Rev.*, July, 1953, p. 313. 56 refs. Survey of the literature.

Air Transportation

The Aircraft Economic Parameter and Its Use in the Comparative Evaluation of All-Cargo Type Aircraft. G. A. Busch. *ASME Semi-Annual Meeting, Los Angeles, Calif., June 29–July 2, 1953, Paper.* 15 pp.

Air-Line Point of View on Status of the Turbine-Powered Transport in the United States. Milton W. Arnold. *Aero. Eng. Rev.*, Aug., 1953, p. 37.

The Influence of Military Aviation on Civil Air Transport. Frederick Handley Page. *J. Inst. Transp.*, May, 1953, p. 107.

MATS and the Gas-Turbine Transport Field. Joseph Smith. *Aero. Eng. Rev.*, Aug., 1953, p. 40.

The Status of the Turbine-Powered Transport in the United States. Frederick B. Lee. *Aero. Eng. Rev.*, Aug., 1953, p. 29.

U.S. Turboprop Transport Future. C. R. Smith. *Aero Dig.*, June, 1953, p. 17.

Airplane Design

The Airplane Growth Factor and How to Control It. Ivan H. Driggs. *U.S., Navy Dept. BuAer RDR 1410*, June, 1953. 45 pp. Design criteria for airframe and components to reduce weight, size, and cost of military aircraft.

Canadair F-86E Sabre 2; One 5,200 lb. s.t. General Electric J-47. J. H. Clark. *The Aeroplane*, June 26, 1953, p. 832, cutaway drawing. Design and structural features.

The Comet Jet-Airliner in Service. Miles Thomas. *Sperryscope*, Second Quarter, 1953, p. 12. Developmental survey; technical features; operational aspects.

The Complexities of Simplification. William I. Stieglitz. *Airline Pilot*, June, 1953, p. 6.

Design Analysis: Chase C-123B. *Aero Dig.*, June, 1953, p. 28, cutaway drawing. A structural and developmental survey; performance characteristics and specifications; safety and other features.

Developing a Naval Jet Fighter. *The Aeroplane*, June 12, 1953, p. 766, folded cutaway drawing (by J. H. Clark). Structural details and performance of the Supermarine Attacker.

Powered Flying-controls; Some Design Considerations. F. J. Bradbury and S. M. Parker. *IME Proc. (B), Hydraulics*, No. 4, 1952, p. 99; Discussion, p. 106; Communications, p. 110. Analysis of mechanically coupled, "on-off" free, proportional, derivative, and other control systems; stability and damper design factors; servo-mechanism testing; reliability and other aspects.

Some Aspects of High Performance Jet Aircraft. W. A. Waterton. *J. RAeS*, June, 1953, p. 375; Discussion, p. 387. Control and stability factors; design and manufacturing tolerances; performance, in terms of wing configurations; the "vision barrier"; summary of general operational experience; economic and other aspects.

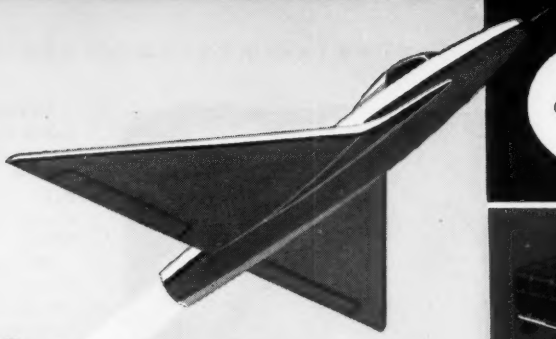
Airports

Aircraft Approach Tolerances; Pilot Problems in the Last 3 Min. of a Successful All-Weather Approach and Landing. Arthur E. Jenks. *Aero. Eng. Rev.*, Aug., 1953, p. 43.

Airport Plan for Jet Aircraft. John Loughlin. *Airports & Air Transp.*, May-June, 1953, p. 38. Description of terminal and apron designed by the Dept. of Civil Aviation, Australia, to protect people from jet noise and blasts.

Aviation Medicine

Acceleration Problems of Naval Air Training. I—Normal Variations in Tolerance to Positive Radial Acceleration. Floyd R. Stauffer. *J. Av. Med.*, June, 1953, p. 167.



Leadership in fuel metering...

FOR JET, RAMJET AND TURBO-PROP ENGINES

Since the first jets of World War II, Bendix Products Division at South Bend has served the aircraft industry in developing and manufacturing fuel metering systems for jet engines. Today Bendix offers unmatched know-how and facilities both in electronic and hydro-mechanical principles for these important components of jets, ramjets and turbo-prop engines.

RESEARCH • A staff devoted exclusively to seeking new and better fuel metering techniques – preparing today for the requirements of tomorrow.

ENGINEERING • An organization that is experienced in applying both *electronic* and *hydro-mechanical* principles. Successful creators of lightweight, serviceable equipment to meet the demands of each new advance in engine design.

MANUFACTURING • Two modern and geographically separate manufacturing divisions. Each capable of building to the most exacting test standards – high quality at reasonable cost.

SERVICE • A world-wide service organization that follows through to see that engine operators obtain full benefit from the quality built into the equipment.

EXPERIENCE • A background of more than thirty years of leadership in designing and building fuel metering systems for both reciprocating and jet engines.

For Your Fuel Metering Requirements Depend Upon Bendix:

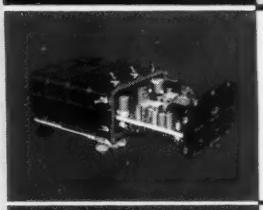
- Hydro-mechanical fuel controls
- After burner controls
- Fuel supply pumps
- Spray nozzles
- Electronic fuel controls
- Turbo-prop controls
- Flow dividers
- Ramjet controls

BENDIX PRODUCTS DIVISION **SOUTH BEND** INDIANA

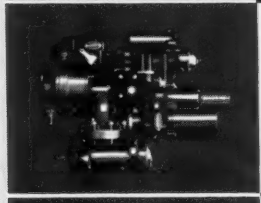
Bendix Aviation Corporation

Bendix Products Division

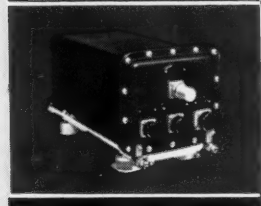
electronic



ELECTRONIC CONTROL Senses engine speeds, gas temperatures and other control factors—then signals fuel requirements to the fuel metering unit.

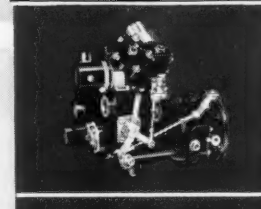


FUEL METERING UNIT Electrically controlled, this unit meters fuel to the engine in accord with signals from the electronic control.

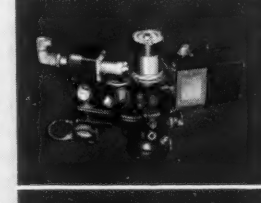


ELECTRONIC AMPLIFIER Maintains a scheduled exhaust turbine temperature by controlling the nozzle area.

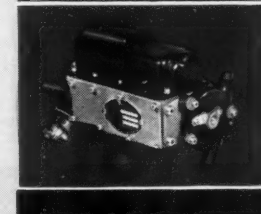
hydro-mechanical



MAIN FUEL CONTROL The control illustrated includes a governor which holds the engine at a selected speed regardless of altitude.



AFTERBURNER FUEL CONTROL Graduates the afterburner thrust by selecting fuel flow in various proportions to mass air flow through the engine.



NOZZLE CONTROL A hydro-mechanical servo control unit which actuates the variable exhaust nozzle mechanism of jet engine.

ELECTRONIC AND HYDRO-MECHANICAL CONTRO

Export Sales: Bendix International Division
72 Fifth Avenue, New York 11, N. Y.

OPPORTUNITIES FOR ENGINEERS in Electronics, Mechanics and Hydraulics —This division of Bendix is among the world leaders in developing and manufacturing a wide variety of products currently in use by commercial as well as military aviation. Investigate your opportunities with Bendix. Write to Administrative Engineering, Bendix Products Division, Bendix Aviation Corporation, South Bend, Ind.

Eliminate *Chances* **of failure!**

*From zero absolute to 12,000 psi gauge.

Today, pressure actuated switches are used in practically all the systems on modern aircraft and missiles. These precision instruments must meet all operational requirements, without failure.

To help in this quest for the perfect airplane, there is available from this single source, a pressure actuated switch for every requirement*; *instruments that are eliminating chances of failure.*

Today, Meletron pressure actuated switches are accepted by every major aircraft and missile manufacturer.

MELETRON® CORPORATION

930 NORTH HIGHLAND AVENUE, LOS ANGELES 38, CALIFORNIA

J. M. WALTHEW CO., Boeing Field, Seattle. THOMSON ENGINEERING SERVICE, 708 Hemphill St., Fort Worth and 732 So. Broadway, Wichita. ROUSSEAU CONTROLS Ltd., 2215 Beaconsfield Ave., Montreal 28, Canada. W. M. HICKS & J. A. KEENETH, 29-27 Forty-first Avenue, Long Island City, New York. JOSEPH C. SORAGHAN & ASSOCIATES, 1612 Eye St., Northwest, Washington 6, D.C.

Altitude Stress in Subjects with Impaired Cardiorespiratory Function. Part C. Studies on Patients with Anemia. John P. Marbarger, Gordon F. Vawter, Pablo H. Wechsberg, and Sanford A. Franzblau. *USAF SAM Project 21-23-019 Rep. 3*, Jan., 1953. 25 pp. 13 refs.

Effective Tracheal and Intrathoracic Pressures Obtained with the D-1 Pressure-Demand Regulator. Richard W. Bancroft and Ulrich C. Luft. *USAF SAM Project 21-1201-0008 Rep. 1*, Apr., 1953. 9 pp. 11 refs.

Enzyme Studies in Acclimatization to High Altitudes. I—Brain Metabolism During Altitude Acclimatization. Harry G. Albaum and Herman I. Chinn. *USAF SAM Project 21-1201-0009 Rep. 1*, May, 1953. 7 pp. 28 refs.

Evaluation of a Modification of the Bennett Respiratory Volume Meter. Clayton S. White and Nils P. V. Lundgren. *USAF SAM Project 21-1402-0001 Rep. 2*, Feb., 1953. 4 pp.

High Altitude—High Velocity Flying With Reference to the Human Factors. IV—Opening Shock of Parachute Descents. A. P. Webster. *J. Av. Med.*, June, 1953, p. 189. 13 refs.

Motoric Responses of the Eyes When Exposed to Light Flashes of High Intensities and Short Duration. S. J. Gerathewohl and H. Strughold. *J. Av. Med.*, June, 1953, p. 200.

Computers

An Analogue Reciprocal Function Unit for Use with Pulsed Signals. P. A. V. Thomas. *Electronic Eng.*, July, 1953, p. 302. A monostable multivibrator unit in which the width of the pulse generated is approximately inversely proportional to the reference voltage.

Capacitively Coupled Field Mapper. E. O. Gilbert and E. G. Gilbert. *Elec. Eng.*, July, 1953, p. 600. An electric analogue mapper for use in analysis of torsional stress, heat transfer, viscous fluid flow, and other two-dimensional problems.

Linear-to-Logarithmic Voltage Converter. R. C. Howard, C. J. Savant, and R. S. Neiswander *Electronics*, July, 1953, p. 156. Conventional triode circuit modified for use with analog computers to provide high-gain conversion over 0.3 to 300-volt range.

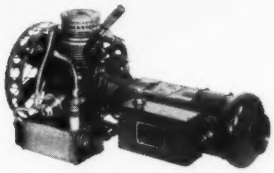
The Relative Merits of A.C. and D.C. as a Signal Source in Analogue Computors. K. H. Simpkin. *Elec. Eng.*, June, 1953, p. 230.

Digital Data Processing—A Key to Technical Progress. Charles R. Wayne. *G-E Rev.*, July, 1953, p. 10. Basic principles.

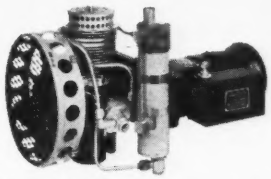
EDVAC Drum Memory Phase System of Magnetic Recording. Donald Eadie. *Elec. Eng.*, July, 1953, p. 590. The general recording method and system components.

Punched-Card Controlled Aircraft Navigation Computer. E. H. Fritze. *Proc. IRE*, June, 1953, p. 734. Theory of course-line computation; application to an omnirange DME navigation system.

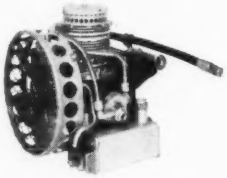
Airborne. 400 cycle — 208v AC drive. Horizontal sump.



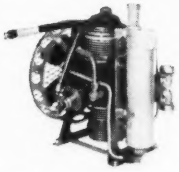
Airborne. 28v — 3½ hp motor. Horizontal sump. Radio noise suppressor.



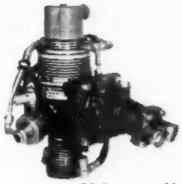
Airborne. 28v — 3½ hp motor. Vertical sump. Radio noise suppressor.



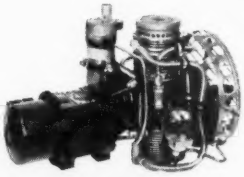
Airborne. Hydraulic drive. 1500 lb. hydraulic system. Horizontal sump.



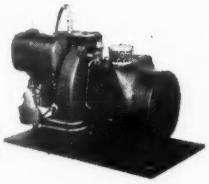
Airborne. Hydraulic drive. 1500 lb. hydraulic system. Vertical sump. Pressurized inlet.



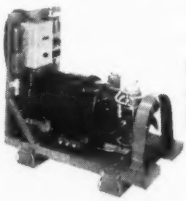
Airborne. Hydraulic drive. 3,000 lb. hydraulic system. Pressurized inlet. Remote sump.



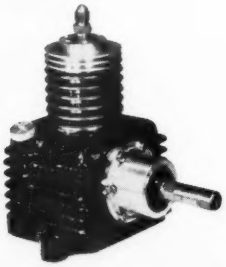
Airborne. 28v—2 hp motor. Vertical sump. At sea level, and at 15,000 ft. delivers 2 cfm of free air compressed to 3,000 psi.



Ground application. Here a portable gasoline motor is used as a driving unit.



Ground application. Here the compressor can be driven by a 60 cycle 220 volt motor.



Airborne. For personal planes. Belt driven. Integral sump. At sea level, delivers ¼ cfm of free air compressed to 500 psi.

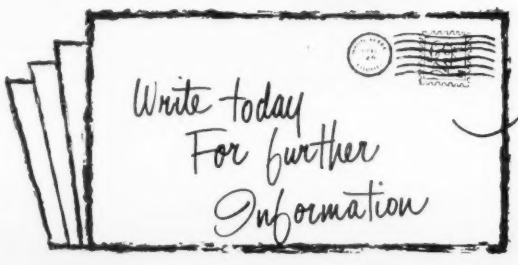
fit a KIDDE 4-stage compressor to your pneumatics needs

in the air . . . on the ground

Except where indicated the Kidde Compressor delivers 4 cfm of free air compressed to 3,000 psi at sea level.

The word "Kidde" and the Kidde seal are trade-marks of Walter Kidde & Company, Inc. and its associated companies.

K Kidde



Kidde

Walter Kidde & Company, Inc.,

911 Main Street, Belleville 9, N. J.

Walter Kidde & Company of Canada, Ltd., Montreal, P. Q.

rugged

Under all conditions, the delicate mechanisms of Kollsman products must function with accuracy and rugged dependability.

- AIRCRAFT INSTRUMENTS AND CONTROLS
- OPTICAL PARTS AND DEVICES
- MINIATURE AC MOTORS
- RADIO COMMUNICATIONS AND NAVIGATION EQUIPMENT

Current production is largely destined for our defense forces; but our research facilities, our skills and talents, are available to scientists seeking solutions to instrumentation and control problems.

kollsman INSTRUMENT CORP.

ELMHURST, NEW YORK • GLENDALE, CALIFORNIA • SUBSIDIARY OF Standard COIL PRODUCTS CO., INC.

Education & Training

Flight Simulators. K. H. Simpkin and E. T. Emms. *Electronic Eng.*, July, 1953, p. 270. Fundamental technical design requirements and general methods of computation; economic aspects and advantages for training purposes.

Electronics

Buyers' Guide Issue. *Electronics.* June Mid-Month, 1953. 912 pp. 27 refs. Reference Sheet Sect. includes graphical short-cuts for engineers in 36 articles; the Directory Sect. covers an alphabetical listing of products, registered trade names, an index of manufactures, and names of distributors of electronic components and equipment.

Charged Disk in Cylindrical Box. W. R. Smythe. *J. Appl. Phys.*, June, 1953, p. 773. Solution of the mixed boundary value problem.

A Comparison of the Informational Capacities of Amplitude- and Phase-Modulation Communication Systems. Nelson M. Blachman. *Proc. IRE*, June, 1953, p. 748.

Radio Technology and the Theory of Numbers. Balth. Van der Pol. *J. Franklin Inst.*, June, 1953, p. 475. Fundamental mathematical applications in radio and electronic theory.

"Cellular" Electronic Construction; A Solderless Assembly Method Using Small Replaceable Units of Standardized Size. *U.S., NBS Sum. TR 1757*, May, 1953. 4 pp.

Printed Circuit Techniques for the Laboratory. Gordon E. Broomhall. *Tele-Tech*, July, 1953, p. 36. A practical photo-resist method for small-quantity production of circuit boards for experimentation.

Filter Insertion Loss in the 10-1000 MC Range. Scott Shive. *Tele-Tech*, June, 1953, p. 95. For interference suppression; instrumentation and measurement techniques.

Signal-to-Noise Ratios in Band-Pass Limiters. W. B. Davenport, Jr. *J. Appl. Phys.*, June, 1953, p. 720.

Regulated Power-Supply Blocks. John H. Bigbee. *Electronics*, July, 1953, p. 176. Compact units providing 70 milliamperes each for smooth voltage control from 70 to 150 volts.

The Effective Number of Pulses Per Beamwidth for a Scanning Radar. Lamont V. Blake. *Proc. IRE*, June, 1953, p. 770.

Differential Inductance Telemeter Equipment for Force and Moment Measurements. R. W. F. Gould. *J. RAeS*, June, 1953, p. 416. NPL apparatus used with models on the Whirling Arm.

Dispositif de Télémesure pour Fusées Supersoniques. Paul Lygrisse. *La Recherche Aéronautique*, July-Aug., 1952, p. 43. In French. Telemetering arrangements for use with supersonic rocket research; description of the apparatus and determination of the position of a model in space by electronic and optical methods.

ANOTHER REASON ALLISON LEADS IN THE AIR

An Allison Technical School instructor leading class discussion on the J35 Turbo-Jet engine.

Training the men behind the men who fly the jets

Around the world there is an ever-growing fraternity of mechanics, engineers and instructors who have earned the title, "Allison Technical School Graduate." More than 10,000 members of the Air Force, Navy and Marines have received diplomas from the Allison Technical School, in Indianapolis.

Students selected by the Armed Forces are usually engineering officers or enlisted personnel with long years of service. They are sent to the school for intensive 4-week courses which involve long hours in the classrooms and extra hours of homework every evening.

Skilled Allison instructors with many years of varied experience make use of modern teaching aids including cutaways of J33 and J35 Turbo-Jet engines, the T38 and T40 Turbo-Prop engines.

But the activities of the Allison Technical School do not stop with the classes at Indianapolis. In addition, Allison instructors from the school go out all over the world to set up classrooms at air bases and aircraft manufacturing plants to teach thousands of other technicians the proper methods of operating and maintaining Allison turbine engines. These men include pilots, flight engineers and technicians from aircraft builders and our own organization.

Yes, thousands of the men behind the men who fly the jets proudly wear the badge, "Allison Technical School Graduate."

GM GENERAL MOTORS

Allison DIVISION OF GENERAL MOTORS, INDIANAPOLIS, INDIANA

World's most experienced designer and builder of aircraft turbine engines—J35 and J71 Axial, J33 Centrifugal Turbo-Jet engines, T38 and T40 Turbo-Prop engines

Synchro Control Transformer
(Actual Size)

Geared Servo Motor
(Actual Size)

Servo Motor-Tachometer Generator
(Actual Size)

miniature
precision components
for high-performance

Servo Systems

Developed and produced by Kearfott, these units exemplify accomplishments of creative engineering teamed with production skill providing performance values of accuracy, speed of response and reliability unique for their size. Advanced design techniques are typified by the unitized stator and housing construction, permitting line-bored relationship of stator and rotor. This makes practical the extremely close concentricity tolerances apparent in improved efficiency of the Servo Motors and the very high accuracy of the companion Synchro. A very rugged structure, stable under extremes of environmental exposure is also provided.

Conforms to Navy BuOrd Size 11
(Maximum Diameter 1-1/16")

TECHNICAL INFORMATION

Synchro—Available as Control Transformer, Transmitter, Resolver, Differential, for 26 or 115 volt 400 cycle operation. Maximum error tolerance is 7 minutes of arc. The hardened pinion shaft may be used as a spline. Terminals for convenient installation and replacement are provided. Other synchros for 60 cycle operation may be obtained. (Basic Type R500).

Servo Motor—The Servo Motor (Basic Type R119) features a very high torque-to-inertia ratio. Motor input is 3.5 watts per phase at 115 volt 400 cycle. Available with high-impedance control winding for operation directly in plate circuit of an Amplifier. Integral precision gear train can be provided. Many other models available including Servo Motors for 60 cycle duty. (Basic Type R303).

Servo Motor-Generator—The motor described above is available with an integral high performance damping generator, providing an output signal of 1/2 volt per 1000 RPM over a 5500 RPM speed range. (Basic Type 420400).

Technical Bulletins on standard Kearfott products are available and will be sent on request. Your inquiries are invited for the development and production of special units for unusual applications. Write today for Bulletin #53 describing our products and facilities.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Kearfott
SINCE 1917
CREATIVE ENGINEERING
PRODUCTION ACHIEVEMENT

KEARFOTT COMPANY, INC., 1150 McBride Ave., Little Falls, N. J.
West Coast Office: 253 N. Vinedo Ave., Pasadena, Calif.
A General Precision Equipment Corporation Subsidiary

Antennas

Anechoic Chamber for Microwaves. Alan J. Simmons and William H. Emerson. *Tele-Tech*, July, 1953, p. 47. Naval Research Lab.-designed broadband absorbing material for measuring and recording antenna radiation patterns in the 2,500 to 25,000 mc. region.

Development of a DME Antenna Transfer Switch. John R. Hoffman, Robert E. Carlson, and Warren E. Haworth. *U.S., CAA TDR 201*, May, 1953. 4 pp.

The Field Radiated by a Ring Quasi-Array of an Infinite Number of Tangential or Radial Dipoles. H. Lottrup Knudsen. *Proc. IRE*, June, 1953, p. 781. 25 refs.

Mutual Impedance of Rhombic Antennas Spaced in Tandem. Jesse Gerald Chaney. (*U.S. Naval Postgraduate School Tech. Rep. 7*, Dec., 1952.) *J. Appl. Phys.*, June, 1953, p. 751.

A New Wide-Angle Microwave Reflector. K. S. Kelleher. *Tele-Tech*, June, 1953, p. 98. A parabolic torus for use as a wide-angle scanning antenna, microwave beam-bend, and for other applications.

The Optimum Linear Array for a Single Main Beam. D. R. Rhodes. *Proc. IRE*, June, 1953, p. 793. WADC-supported investigation at Ohio State University Research Foundation, Columbus, Ohio.

Simplification for Mutual Impedance of Certain Antennas. Jesse Gerald Chaney. (*U.S. Naval Postgraduate School Tech. Rep. 6*, Nov., 1952.) *J. Appl. Phys.*, June, 1953, p. 747.

Circuits & Components

The Effects of Terminations and Dissipation on the Insertion Loss of Some Simple Ladder Filters. M. Strasberg. *Proc. IRE*, June, 1953, p. 777.

Fundamentals in the Behavior of Electrets. W. F. G. Swann. *J. Franklin Inst.*, June, 1953, p. 513.

Heat Transfer in Subminiature Electronic Equipment. D. T. Drake. *Tele-Tech*, June, 1953, p. 111. Design requirements for proper cooling of airborne devices.

Printed Circuits and Miniaturization. P. Eisler. *Elec. Eng.*, June, 1953, p. 234.

Quality Control of Airborne Equipment. Bernard Heicht. *Tele-Tech*, June, 1953, p. 119. Discussion of USAF specification MIL-Q-5923A as applied to electronic equipment manufacture.

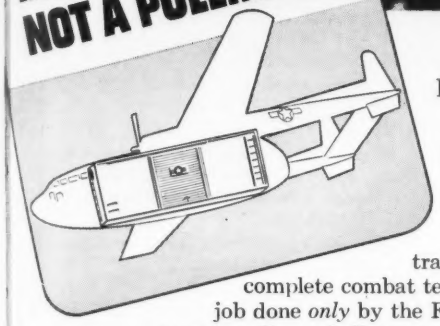
Transducteurs et Amplificateurs Magnétiques. II—Transducteur avec Autoexcitation. III—Transducteur Triphasé. K. Kuhnert and M. Delattre. *France, ONERA Pub. 57*, 1953. 197 pp. 166 refs. In French. A general analysis of magnetic transductors and amplifiers, including a 10-page bibliography for the period 1903-1950; transductors with and without self excitation; three-phase applications.

Wiener's Theory of Linear Filtering. D. A. Bell. *Wireless Engr.*, June, 1953, p. 136.

Analysis of a Single-Ended Push-Pull Audio Amplifier. Chai Yeh. *Proc. IRE*, June, 1953, p. 743. A theoretical circuit analysis.

FLIES MASSIVE EQUIPMENT READY FOR ACTION!

FREIGHT TAKES A BOXCAR... NOT A PULLMAN!



Rapid preparation of advance bases calls for fast delivery of bulky military equipment and combat troops ready for action—without the danger, delay and cost entailed in re-assembling and equipping. Delivering big tractors, bulldozers, 10-ton scrapers or complete combat teams—*ready to operate* is the kind of job done *only* by the Fairchild C-119. Designed from nose to twin-tail as a *bulk cargo airplane*, the famous combat proven "Flying Boxcar" has the wide-open, easy-loading capacity to meet the ever-changing cargo needs of our Armed Forces. Produced at the lowest airframe-cost-per-pound in the industry, the C-119 also has the lowest *cost per ton-mile* of any bulk cargo carrier in service today.

EXCLUSIVE FEATURES FOR ADVANCE BASE OPERATIONS:

Increased payload • Better bulk Cargo Clearance and Distribution • Shorter Take-offs and Landings • Rough Field Landing Gear • Crew Bail-Out Chute • Provision for External Fuel

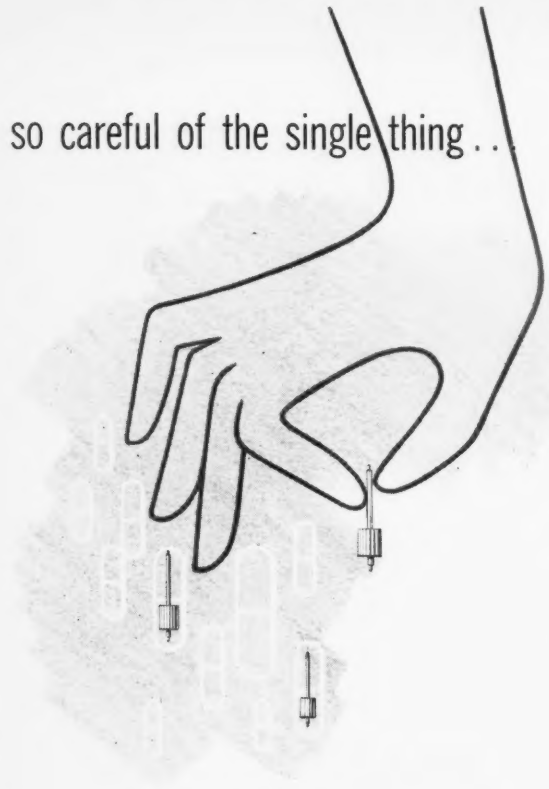
ENGINE AND AIRPLANE CORPORATION

FAIRCHILD

Aircraft Division

HAGERSTOWN, MARYLAND

Guided Missiles Division, Wyandanch, L. I., N. Y.
Engine Division, Farmingdale, L. I., N. Y.



Packaging high precision components in a protective capsule is an end-activity at **RDM** but it is representative of the organization—the field of operation, method and facilities.

Field of Operation: Custom-made, Swiss precision components. Whether it be electrical, mechanical or electronic devices, **RDM** is ever ready to engineer your components . . . and then manufacture where research and development end.

Method: Emphasis on the particular. Component reliability is vital to fine devices and can only be assured by undivided attention to the single part. Quality control at **RDM** is maintained by a continuous inspection of all processes . . . with the final result safely encapsuled.

Facilities: A complete one-stop service to the manufacturer of precision devices. All precision primary and secondary processes are accomplished under one roof. **RDM** alone assumes full responsibility for the dependable reproduction of your most exacting specifications . . . and for delivery on time. Costly and time-consuming bottlenecks are eliminated when you make **RDM** part of your production line.

That's the story of **RDM** in a capsule . . . quality, reliability, economy on crucially precise components.

Our brochure is more detailed. Write.

THE AMERICAN NAME IN SWISS PRECISION

RDM

RESEARCH DEVELOPMENT MANUFACTURE, INC.

431 E. COLLOM STREET, PHILADELPHIA 44, PENNSYLVANIA

PINIONS • GEARS • SHAFTS • PIVOTS • BEARINGS • SPECIAL SCREWS

Conductance Curves Speed Pentode R-C Amplifier Design. Keats A. Pullen. *Tele-Tech*, July, 1953, p. 44. Design technique and procedure.

A Differential Input-Stage for Low-Frequency Amplifiers. V. H. Attree. *Elec. Eng.*, June, 1953, p. 260. 14 refs. Used at Fluid Motion Laboratory, University of Manchester, England, in experimentation on aerodynamic noise in turbulent airflow.

Direct-Coupled Instrument Amplifier. Geoffrey H. Grey. *Radio & TV News, Radio-Electronic Eng. Sect.*, July, 1953, p. 3. Amplifier characterized by a voltage gain of 200 and a frequency response up to 500 kc.; for oscilloscopes and other applications.

Design of Cathode Followers. Robert L. Whittle. *Tele-Tech*, July, 1953, p. 52.

Distributed Amplifier Theory. Delmar V. Payne. *Proc. IRE*, June, 1953, p. 759. Mathematical analysis of the operation of the plate line.

Feedback Amplifiers with Stabilized Output Impedances. Norris C. Hekimian *Tele-Tech*, June, 1953, p. 103.

Harmonic Distortion and Negative Feedback. R. O. Rowlands. *Wireless Engr.*, June, 1953, p. 133.

A Low-Noise Amplifier for 200 MC. Robert Lowell. *Tele-Tech*, June, 1953, p. 106. Use of the 416A microwave triode; telemetering applications at the Naval Research Lab., White Sands, N. M., in the upper-atmosphere research program.

Portable Preamplifier for Vibration Analysis. R. K. Vinycomb and L. D. Crawley. *Electronics*, July, 1953, p. 164.

A Simple Low Frequency Amplifier. J. R. Beattie and G. K. T. Conn. *Electronic Eng.*, July, 1953, p. 299. Use of a twin-resistance-capacitance network with independant controls of frequency and of the Q-factor or pass band, for the 1 to 3 cycles per sec. tuning range; measurement of the time of response of radiation thermocouples and other applications.

The Magnetic Amplifier. Engineering Dept. Staff. *Aerovox Res. Worker*, Feb., 1953, p. 1. Basic principles and theory of operation; comparison with other types.

The Magnetic Amplifier. W. C. Johnson. *Elec. Eng.*, July, 1953, p. 583. Fundamental principles; external feedback and self-saturating circuits; advantages and limitations.

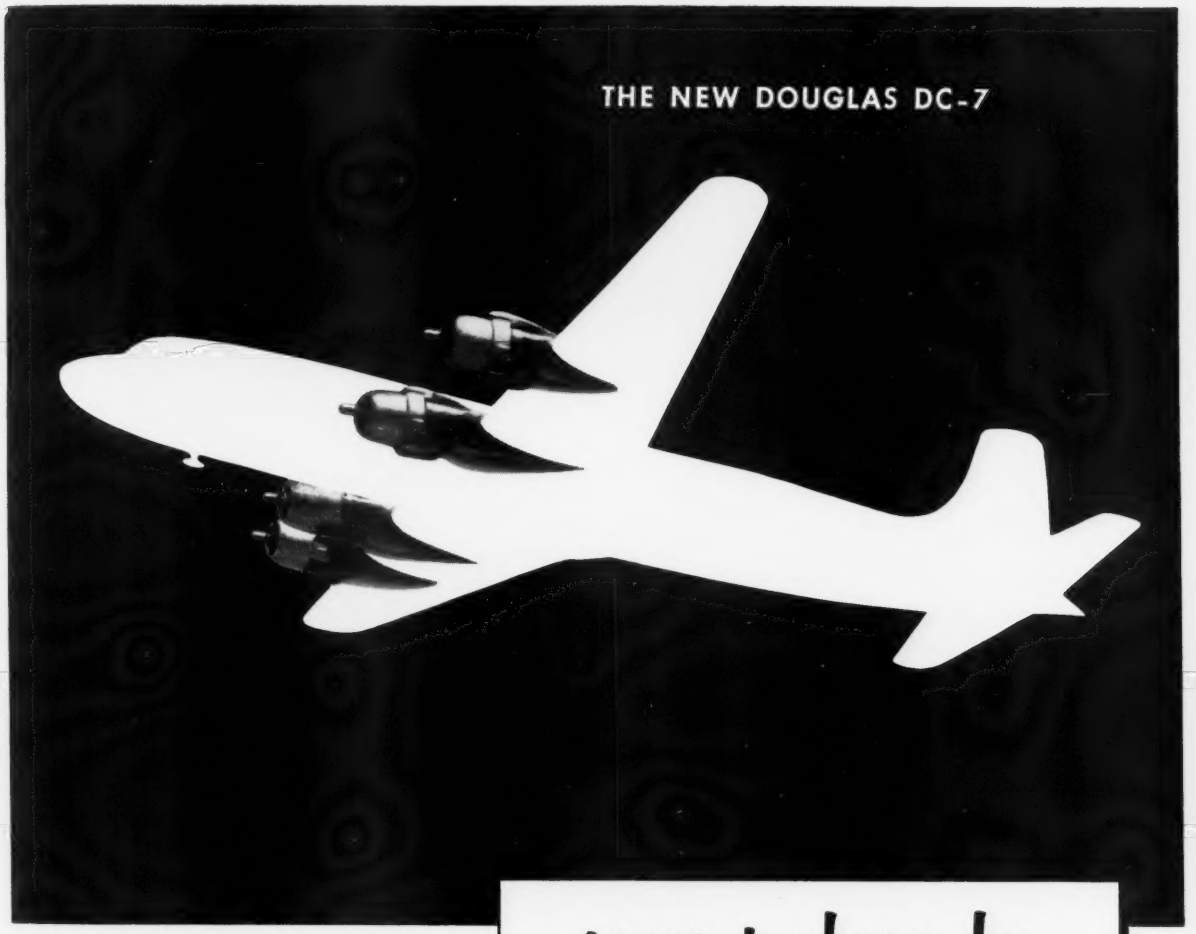
Magnetic Amplifier Transient Analyzer. W. A. Geyger. *Electronics*, July, 1953, p. 189. NOL investigations.

Magnetic Amplifiers. II. Siegfried R. Hoh. *Tele-Tech*, June, 1953, p. 114. Circuit design principles; general characteristics; applications.

Magnetic Amplifiers for Airborne Applications. J. K. McKendry. *Tele-Tech*, July, 1953, p. 32.

The Darlington Problem. Louis Weinberg. *J. Appl. Phys.*, June, 1953, p. 776. Procedure for realization of certain network transfer functions.

Tolerance Coefficients for R-C Networks. Charles Belove. *J. Appl. Phys.*, June, 1953, p. 745. Calculation of the departure of actual network behavior from design characteristics attributable to the use of nonideal components.



Here's the big, handsome, DC-7 – Douglas' latest commercial airplane. This picture shows off the power packages built for the DC-7 by Rohr . . . world's largest producer of ready-to-install power packages for both commercial and military planes. In addition, Rohr Aircraftsmen currently are producing more than 25,000 different parts for all types of airplanes.

power packages by

ROHR

WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES

ROHR AIRCRAFT CORPORATION

CHULA VISTA AND RIVERSIDE CALIFORNIA

Leadership Demands Constant Achievement

Built to get there NOW!

F-94C Starfire combines defense with economy!

No fighter-interceptor can get into the air quicker, and none can climb faster than the Lockheed F-94C Starfire. This new all-weather interceptor for the U.S. Air Force is now defending key American cities from possible air attack. The Starfire was designed to reach target altitude in record time.

Combining greater flight availability and lower maintenance costs with superlative performance, the F-94C Starfire actually delivers more defense for your dollar.

Lockheed

AIRCRAFT CORPORATION

BURBANK, CALIFORNIA, AND MARIETTA, GEORGIA

Look to Lockheed for Leadership

Lockheed

Builds Plane No. 25,000 and Jet No. 5,000

Lockheed airplane Number 25,000 rolled off the production lines recently in Lockheed's Burbank, California, plant. Significantly, it was an F-94C Starfire Jet Interceptor, newest member of Lockheed's pioneering jet aircraft family. Later, another Lockheed Starfire became the 5,000th Lockheed jet to be built.

There's a reason for the quantity production of F-94C Starfires. Here's a military jet that does an outstanding job and saves money, too.

Here's How It Does It

Economy is important with the Air Force, and here's how the Starfire helps on the budget:

An economical airplane is one that performs its mission with greatest efficiency and offers maximum availability on the ready line. Maximum time between servicings means *lower maintenance costs*. More important, it means *fewer planes are needed*. The U.S.A.F. provides both types of economy with the Starfire.

2-Man Team Helps

Since the Lockheed Starfire is a 2-place interceptor, it utilizes the cooperative efficiency of a 2-man team to compute the tactical problem and perform all other split-second operations of intercepting an enemy at 600-mph-plus speeds.

This all-weather interceptor is equipped with automatic electronic controls — Hughes Radar System, Westinghouse Automatic Pilot, Sperry Zero Reader—and other advanced devices, making it very nearly an automatic airplane.

A "Pilot's Airplane"

Reports coming in from the field indicate that Lockheed has again produced a "pilot's airplane." Air Force pilots like the Starfire and like to fly it. They find it simple to fly and rock-steady under actual instrument conditions.

Here is the happy combination of 4 important factors in one reliable airplane: (1) Superlative performance — (2) Easy maintenance — (3) Pilot popularity — (4) More defense for your dollar.

Blocking Oscillators. K. G. Beauchamp. *Elec. Eng.*, June, 1953, p. 239. 20 refs. Application to frequency dividers, low-impedance pulse generators, and other radar equipment.

Electrical Oscillations; A Physical Approach to the Phenomena. A. W. Gillies. *Wireless Engr.*, June, 1953, p. 143.

The Equivalent Q of RC Networks. D. A. H. Brown. *Electronic Eng.*, July, 1953, p. 294. Phase-shift oscillator circuit application.

A Low Distortion Audio Signal Generator. George Ellis Jones, Jr. *Radio & TV News*, July, 1953, p. 58. Generator for the frequency range from 11 to 120,000 cycles per sec.

Mechanism of the Synchronization of *LC*-Oscillators. J. Van Slooten. *Phillips Tech. Rev.*, Apr., 1953, p. 292.

A Note on Moving Poles in Nonlinear Oscillating Systems. William B. Wrigley. *Proc. IRE*, June, 1953, p. 774. Mathematical analysis.

An Oscillator with Constant Output Voltage. L. Ensing and H. J. J. van Eyndhoven. *Philips Tech. Rev.*, Apr., 1953, p. 304. Application of the general regulating principle.

Oscilloscope Voltage Calibrator. Alvin B. Kaufman. *Radio & TV News, Radio-Electronic Eng. Sect.*, July, 1953, p. 15. To provide a square-wave calibrating voltage at frequencies 1–20,000 cycles per sec.

Pulse Duration Modulation. Henry T. Peretko. *Radio & TV News, Radio-Electronic Eng. Sect.*, July, 1953, p. 8. PDM characteristics, advantages, and disadvantages; design features of an experimental modulator and demodulator.

S-Band Sweep Generator and Test Set. Roy E. Larson. *Tele-Tech*, June, 1953, p. 116. To measure frequency response of traveling-wave tube; fixed and thermally-tuned klystrons used to give a 1000 mc. sweep.

Symmetrical Properties of Transistors and Their Applications. George Clifford Sziklai. *Proc. IRE*, June, 1953, p. 717.

Transistor Physics Simplified. I. S. P. Gentile and P. J. Barotta. *Radio & TV News*, July, 1953, p. 44. Operational principles; characteristics and limitations.

Transistors. V—Applications in Trigger Circuits. Thomas Roddam. *Wireless World*, June, 1953, p. 256.

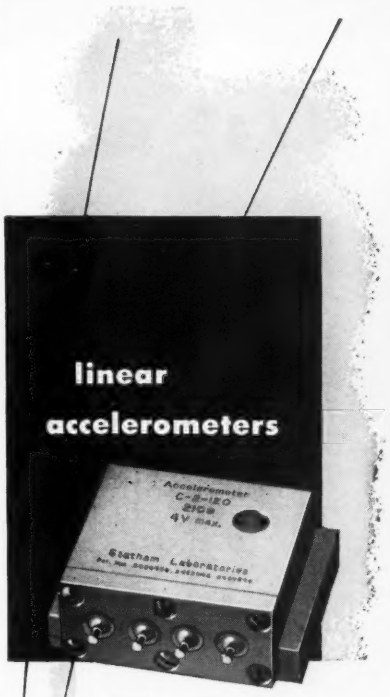
Transistors: Theory and Application. V—Point-Contact Transistor Operation. Abraham Coblenz and Harry L. Owens. *Electronics*, July, 1953, p. 158.

Electronic Controls

How Electronics Controls Guided Missiles. John M. Carroll. *Electronics*, July, 1953, p. 130. Details of a V-2 control system.

A Multirange Sensitive Control. Winston Alderson and Douglas Erickson. *Radio & TV News, Radio-Electronic Eng. Sect.*, July, 1953, p. 6. A photocell-actuated control device developed by Ryan Aeronautical Co. for use with low-torque shaft instruments.

Optimization of Nonlinear Control Systems by Means of Nonlinear Feedbacks. R. S. Neiswander and R. H. MacNeal. *CIT Paper*, Jan. 14, 1953. 32 pp. 13 refs. A selection of a category of non-



Linear accelerometers are manufactured by Statham Laboratories for measurement in ranges from ±0.5g to ±1,000g. Unbonded strain gage accelerometers have higher natural frequency than is usually attainable with other types of pickoffs. For maximum possible output, the mechanical construction of these instruments is such that movement of the suspended mass produces a change of resistance of all four arms of the complete balanced bridge. The resistive nature of the bridge permits the use of these accelerometers in either A.C. or D.C. circuits.

Please request Bulletin No. 4.0.

Statham
LABORATORIES
• Los Angeles 64, Calif.

The PROTECTION of ALUMINUM

Drawing courtesy of Piasecki Helicopter Corporation, Morton, Pennsylvania

THE H-21 Piasecki Tandem Helicopter—the "Work Horse"—is ideally suited for rescue work in areas inaccessible by other means, and in all kinds of rough weather. For durable paint adhesion and high corrosion-resistance aluminum parts of the "Work Horse" are Alodized. The "Alodine" protective coating chemical bonds paint, extends paint life, and protects unpainted aluminum. Because of its economy, effectiveness, and ease of application, the Alodizing process is finding wide-spread use in the aircraft field and in other industries fabricating products of aluminum. Alodized aluminum meets the requirements of Military Specification MIL-C-5541. Write or call for coating and process data on "Alodine".

Visit Our Display in
Space 1104
Main Exhibition Hall
Cleveland
Public Auditorium
at the
National Metal Exposition
October 19th - 23rd

CHEMICALS ACP PROCESSES

"Alodine" Trade Mark Reg. U. S. Pat. Off.

AMERICAN CHEMICAL PAINT COMPANY
General Offices:
AMBLER, PENNSYLVANIA
Detroit, Mich. Niles, Calif. Windsor, Ont.

linear systems; characteristics of an intentionally nonlinear element added to the feedback; the shaping of this nonlinear element to provide optimum response in the saturated region of operation.

A Simple Connection Between Closed-Loop Transient Response and Open-Loop Frequency Response. J. C. West. (*IEE Measurements Sect. Paper 1378.*) *Proc. IEE*, Part II, June, 1953, p. 201; Discussion, p. 209. A theoretical generalization of the Nyquist phase-margin behavior concept to relate the damping of the principal oscillatory mode of a closed-loop feedback system.

Sinusoidal Analysis of Nonlinear Control Systems. E. C. Johnson. *Elec. Eng.*, July, 1953, p. 626. Abridged.

Electronic Tubes

Calculation of a Waveguide-Loaded Resonator for Interdigital Magnetrons. Gunnar Hok. *Proc. IRE*, June, 1953, p. 763.

Fast-Response High-Current Thyratron Power Supplies for Inductive Loads. J. H. Burnett. *Elec. Eng.*, July, 1953, p. 627. Use as amplifiers in servomechanism or regulator circuits.

A New High-Speed Cathode-Ray Tube. Harold J. Peake and Robert W. Rochelle. *Tele-Tech*, July, 1953, p. 58. Characteristics of type K 1056 for recording transient-voltage waveforms, with spot velocities as high as 13,000 in. per microsec.

Surface Films and Field Emission of Electrons. F. Llwellyn Jones and C. G. Morgan. *Proc. Royal Soc. (London), Ser. A*, June 9, 1953, p. 88. 22 refs.

Measurements & Testing

Diagnosis of Distortion; The "Difference Diagram" and Its Interpretation. E. R. Wigan. *Wireless World*, June, 1953, p. 261. An oscilloscope-trace technique using a test frequency of 1000 cycles per sec.

A Direct Reading Precision Polarograph. H. A. Dell and C. H. R. Gentry. *Philips Tech. Rev.*, Mar., 1953, p. 257. New apparatus utilizing a cathode-ray tube for both quantitative and qualitative metallurgical analysis; measuring procedure.

Electronics Applied to the Measurement of Physical Quantities. G. E. Bennett, G. R. Richards, and E. C. Voss. *Gt. Brit. ARC R&M 2627* (Sept., 1947), 1952. 124 pp. 92 refs. BIS, New York. $8.65.

A Harmonic-Response-Testing Equipment for Linear Systems. D. O. Burns and C. W. Cooper. (*IEE Measurements Sect. Paper 1386.*) *Proc. IEE*, Part II, June, 1953, p. 213; Discussion, p. 221. For analyzing servomechanisms, amplifiers, passive networks, regulators, and other linear devices.

High Resistance Bridge for Conductivity Measurements. M. Unz. *J. Sci. Instr.*, June, 1953, p. 179. 14 refs.

An Improved Scanning Electron Microscope for Opaque Specimens. D. McMullan. (*IEE Measurements Sect. Paper 1381.*) *Proc. IEE*, Part II, June, 1953, p. 245; Discussion, p. 257. Design and basic principles including detectors, amplifiers, display and recording system, scan-

"Dialed Flight"

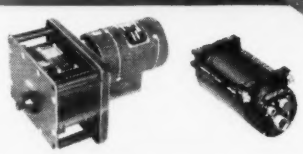
for the REPUBLIC THUNDERJET

Flying at near sonic speed on a long-range ground support or bombing mission, the F-84 Thunderjet pilot needs a break, and gets it—welcome relief provided by his Lear Autopilot.

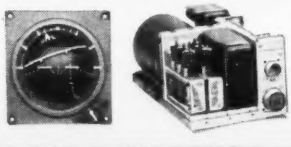
On the straight-away flight he can sit relaxed, conserving his energies for procedures requiring human decision. He changes course simply by "dialing" the kind and degree of change required on one of three knobs on his autopilot controller, or permits his Lear Autopilot to take over completely on the straight and level course. To a Lear Servo Unit, his Lear Autopilot transmits a signal—and smoothly, automatically, his craft takes on the desired attitude of flight.

Lear precision-engineered Control and Actuating systems and components, used extensively in military aircraft of all types, and in aircraft operated by major airlines, are aiding in the development of smoother, more economical and safer flight.

LEAR AUTOPILOT SYSTEMS— compact, light weight, automatically perform any normal flight maneuver. Used in commercial and military single, multiple-engine and jet aircraft.



DAMPING CONTROLS



VERTICAL GYRO INDICATORS

Lear®

Advancing the Frontiers of Flight

GRAND RAPIDS DIVISION

110 IONIA AVE., N.W., GRAND RAPIDS 2, MICHIGAN

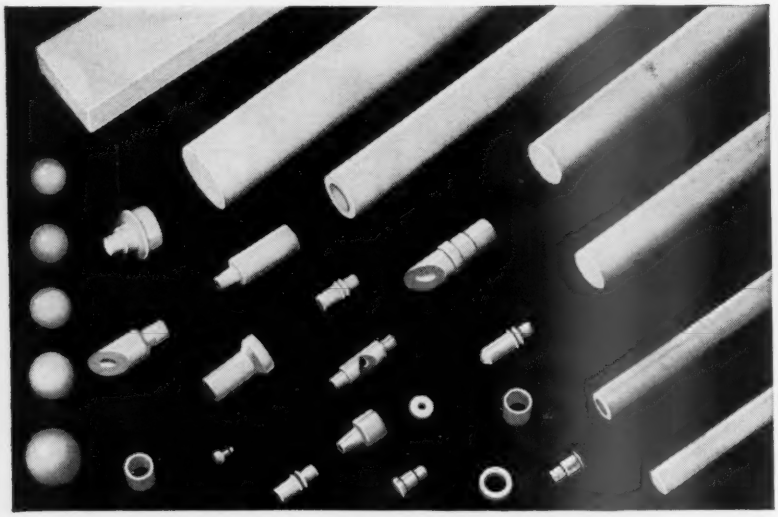
•

LEAR-ROMEC DIVISION, ELYRIA, OHIO
LEARCAL DIVISION, LOS ANGELES, CALIFORNIA
LEAR, INCORPORATED, GRAND RAPIDS 2, MICHIGAN

OTHER INSTRUMENT PRODUCTS:
Automatic Approach Couplers and Flight Controls.
Control Mechanism Gyros • Remote Reading Gyro Instruments.
Missile Flight Controls • Rate Gyros.

teflon*

. . . and We Can Deliver!



EXTRUDED
MOLDED **ROD and TUBE**

Small Machined Parts! Sheets!

Heavy demand has put many TEFLON fabricators in a "back ordered" condition. The effect — stymied or crippled production on your end.

At FLEXROCK we have licked this problem. New TEFLON producing equipment has been added. We have substantially increased capacity. We can't take on all things just yet. But soon we will be ready to "throw the book at you" with a complete range of TEFLON services. RIGHT NOW we are set to ship you TEFLON Rod and Tube, extruded or molded, Sheets, and small parts — no matter how intricate — machined from Rod and Tube. We can promise good delivery — yes, FAST DELIVERY . . . with closest possible tolerances on your small parts. Tell us your needs — we will be happy to quote delivery and price.

**DuPont trade-mark for tetrafluoroethylene resin*

for teflon it's
FLEXROCK
PHILADELPHIA 4, PA.

SEND US YOUR "SPECS" LET US QUOTE

FLEXROCK COMPANY, 3604-J Filbert St., Phila. 4, Pa.

☐ *We are enclosing sample, specs, and quantity for our TEFLON requirements. Please furnish quotation.*
☐ *Please send us your TEFLON Bulletin including stock list.*

Name .....
Company .....
Address .....
City ..... *Zone* ..... *State* .....

ning circuits and modes of operation; application to examination of structure of metals.

Measuring Methods for Some Properties of Ferroxcube Materials. C. M. van der Burgt, M. Gevers, and H. P. J. Wijn. *Philips Tech. Rev.*, Mar., 1953, p. 245. Application of technique used in high-frequency radio and radar measurements.

Methods and Equipment for Transistor Testing. B. J. O'Neill and Arthur Gutterman. *Electronics*, July, 1953, p. 172.

Microwave Technique for Studying Discharges in Gases. M. A. Lampert and A. D. White. *Elec. Commun.*, June, 1953, p. 124.

Navigation Aids

Continuous-Indicating Loran Navigator. Roger B. Williams, Jr. *Electronics*, July, 1953, p. 166. Instantaneous fixes for high-speed aircraft utilizing a 12-tube servo-relay attachment to the standard Sperry Mark-2 indicator.

The Measurement of VOR Polarization Errors. Sterling R. Anderson and Wendell A. Law. *U.S., CAA, TDR 202*, May, 1953. 12 pp.

Nonquantized Frequency - Modulated Altimeter. Henry P. Kalmus, John C. Cacheris, and Herbert A. Dropkin. (*U.S., NBS Res. Paper 2413.*) *U.S., NBS J. Res.*, Apr., 1953, p. 215.

Transmission Lines

The Electromagnetic Transmission Characteristics of the Two-Dimensional Lattice Medium. Herbert S. Bennett. *J. Appl. Phys.*, June, 1953, p. 785. 61 refs.

Slot Coupling of Rectangular and Spherical Wave Guides. L. B. Felsen and N. Marcuvitz. *J. Appl. Phys.*, June, 1953, p. 755.

Synthesis of Uniform Transmission Line. D. W. C. Shen. *Electronic Eng.*, July, 1953, p. 287. Mathematical synthesis by an infinite number of four-terminal networks.

Wave Propagation

The Collision Frequency of Electrons in the Ionosphere. Marcel Nicolet. *J. Atmospheric & Terrestrial Phys.*, May, 1953, p. 200. 34 refs. USAF-sponsored radio fade-out, wave propagation, and other studies at the Ionosphere Research Lab., The Pennsylvania State College.

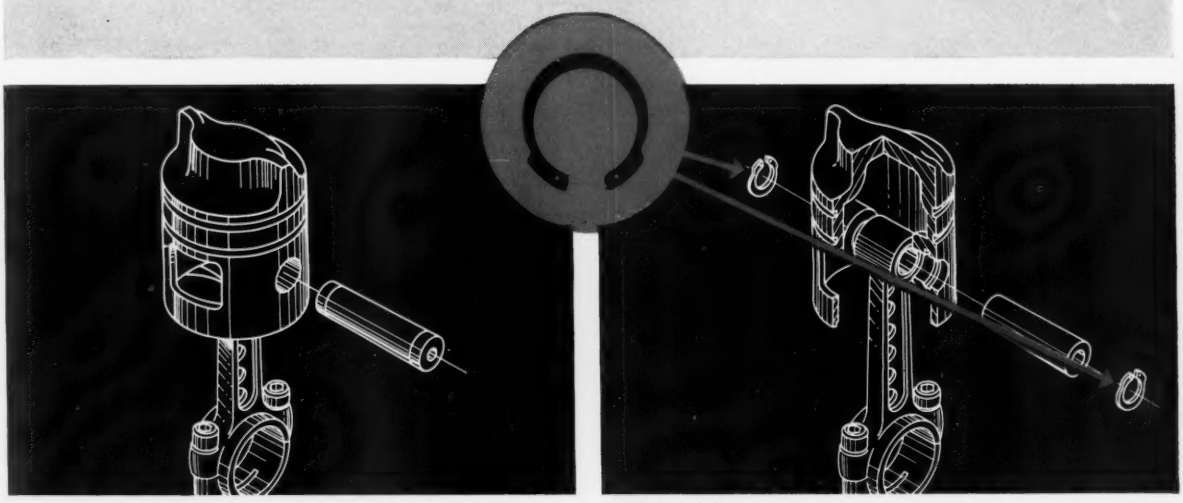
Instrumentation for Measuring Changes in Phase of Ionospheric Echoes. Robert E. Jones. *Rev. Sci. Instr.*, June, 1953, p. 433. USAF-sponsored research at the Ionosphere Research Lab., The Pennsylvania State College; system consists of a frequency converter, radio-frequency interferometer, and recorder.

Proposed Use of a Cylindrical Surface Wave Resonator for the Determination of the Velocity of Short Electromagnetic Waves. H. M. Barlow and A. E. Karbowiak. *Brit. J. Appl. Phys.*, June, 1953, p. 186.

Equipment

Centrifugal Pumps. Arvid E. Roach. *Mach. Des.*, June, 1953, p. 183. Nomo-

2 Waldes Truarc Rings Replace 2 End Plugs ...Eliminate 3 Operations...Save $.066 Per Unit



OLD WAY Two inserted-plug type wrist pin locks hold wrist pin in place. 3 operations involved: costly machining, pressing in place, post-assembly machining. Costly maintenance problem—resulting from end plugs hammering loose.

TRUARC WAY Two Truarc Inverted Retaining Rings (Series 5008) hold wrist pin in place. Truarc Rings snap into grooves easily cut in piston, provide positive lock . . . practically eliminate maintenance costs. Quick assembly, disassembly.

Titan Chain Saws, Inc., Seattle, Washington, uses 2 Waldes Truarc Rings to replace old-style inserted-plug type wrist pin locks in their Titan chain saws. Use of Waldes Truarc Retaining Rings eliminates 2 press fit end plugs. Machining of plugs, pressing in place, finish machining—no longer required. Truarc way holds rejections to a minimum. Unit efficiency is greatly increased.

Redesign with Truarc Rings and you, too, will cut costs. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together.

USE OF 2 WALDES TRUARC RINGS PERMITTED THESE SAVINGS PER UNIT:

OLD WAY	
Cost of 2 end plugs Cost of pressing in and machining	$ .169
TRUARC WAY	
Cost of grooving piston Cost of 2 Truarc Rings	.103
Saving per Unit	**$ .066**

Waldes Truarc Rings are precision-engineered . . . quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Waldes Truarc Retaining Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

For precision internal grooving and undercutting . . . Waldes Truarc Internal Grooving Tool.

SEND FOR NEW CATALOG

WALDES

TRUARC

REG. U.S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U.S. PATENTS: 2,382,947; 2,382,948; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,380; 2,483,383; 2,487,602; 2,487,803; 2,491,306; 2,509,081 AND OTHER PATENTS PENDING.

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.

Please send me the new Waldes Truarc Retaining Ring catalog.

(Please print) AE-095

Name.....

Title.....

Company.....

Business Address.....

City.....Zone.....State.....

DEPARTMENT OF TECHNOLOGY BUFFALO PUBLIC LIBRARY

grams for determining impeller speed and size effects.

Lifeing of Aircraft Equipment and Instruments. H. B. Cundall. *J. RAeS*, June, 1953, p. 391. Maintenance and replacement requirements.

Hydraulic & Pneumatic

Dynamic Behavior of Pneumatic Devices. I. L. A. Gould and P. E. Smith. *Instruments, J. ISA* Sect., June, 1953, p. 886. Theoretical analysis of the transfer function.

How Compressed Air Serves the Aircraft Industry. Edmond C. Powers. *Aero Dig.*, June, 1953, p. 26.

Hydraulic Control Systems. III—Pilot and Electrical Control. R. Hadekel. *Mach. Des.*, June, 1953, p. 168. Basic design and principles for aid in development of circuits of maximum simplicity and effectiveness.

Hydraulic Fuses . . . What Are They? How Do They Work? Harry Hedland. *Appl. Hydraulics*, June, 1953, p. 74. Weight and efficiency requirements in aircraft hydraulic systems; safety factors.

Régulation Hydraulique d'Alimentation des Turbomachines. Basile Demtchenko. *France, Min. de l'Air PST 277*, 1953. 182 pp. 140 refs. In French. Mathematical analysis of hydraulic regulatory systems to control fuel supply in turbomachines.

Shock Absorbers. J. W. Kinchin and C. R. Stock. *IME Auto. Div. Proc.*, Part II, 1951-52, p. 67; Discussion, p. 78; Author's reply, p. 85. Analysis of different types of vibration dampers, including the Dowty hydraulic spring for aircraft landing gear.

Valves Are in the Loop. II. E. Wolff. *Instrumentation*, Second Quarter, 1953, p. 30. Functions of diaphragm motor-control valves.

Series motor suitable for many intermittent duty applications where space and weight are important considerations.
Lightweight universal motor for portable devices requiring a self-ventilated, high-speed motor.
DEPENDABILITY
IS COMBINED WITH
LOW WEIGHT IN

★ Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

The wide use of Lamb Electric Motors in aircraft components, home appliances, portable electric tools and other portable devices is impressive evidence of the fact that they combine thorough dependability with low weight.

To obtain these and the other advantages of Lamb Electric specially engineered motors, it is important that the motor be considered while the product is still in the design stage.

The Lamb Electric Company *Kent, Ohio*
In Canada: Lamb Electric — Division of Sangamo Company Ltd.— Leaside, Ontario

THEY'RE POWERING AMERICA'S *Finest* PRODUCTS

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

Flight Operating Problems

Turbine-Powered Commercial Aircraft. Dewitt C. Ramsey. *Aero. Eng. Rev.*, Aug., 1953, p. 34. Survey of operating problems in jet transportation, including noise reduction, safety precautions, and operational hazards.

Propeller-Noise Charts for Transport Airplanes. Harvey H. Hubbard. *U.S., NACA TN 2968*, June, 1953. 47 pp. 11 refs.

Some Aspects of Noise from Supersonic Aircraft. G. M. Lilley, R. Westley, A. H. Yates, and J. R. Busing. *J. RAeS*, June, 1953, p. 396. 24 refs. Study of shock wave patterns in accelerated and retarded flight at transonic and supersonic speeds; the Doppler effects; analysis of human reactions in ground observations.

Ice Prevention & Removal

Comparison of Several Methods of Cyclic De-Icing of a Gas-Heated Airfoil. Vernon H. Gray and Dean T. Bowden. *U.S., NACA RM E53C27*, June 22, 1953. 66 pp.

Effect of Ice and Frost Formations on Drag of NACA 65_1-212 Airfoil for Various Modes of Thermal Ice Protection. Vernon H. Gray and Uwe H. von Glahn. *U.S., NACA TN 2962*, June, 1953. 68 pp.

Meteorological Design Requirements for Icing Protection Systems. D. Fraser. *Canada, NAE LR-49*, Mar., 1953. 38 pp. 17 refs.

Note on the Flight Testing and Assessment of Icing Protection Systems. D. Fraser. *Canada, NAE LR-50*, Mar., 1953. 9 pp.

Flight Safety & Rescue

Development of Crash-Survival Design In Personal, Executive and Agricultural Aircraft. Hugh De Haven. *Cornell U. Med. Coll. Crash Injury Res. Paper*, May, 1953. 20 pp.

Escape Devices. A. M. Mayo. *Aircraft* (Australia), Feb., 1953, p. 26. 12 refs. Design survey of jettisonable and other escape equipment.

Hill Standing Waves and Safety Heights. D. Mason. *Sailplane & Glider*, June, 1953, p. 9. Effects of lee waves and safety requirements.

Some Observations on Safety of Life at Airports. Jerome Lederer. *Transp. & Commun. Rev.*, Jan.-Mar., 1953, p. 39.

Systems Phenomena in Air Operation; Internal Research. Maurice H. Slud. *Cornell Aero Lab. Rep. JA-848-G-1*, Dec. 15, 1952. 48 pp. 14 refs. Air-safety engineering and an analysis of accidents.

Fires

Aircraft Fire Extinguishment. II—The Effect of Air Flow on Extinguishing Requirements of a Jet Power-Plant Fire

Instruments by

WESTON

Weston Model 1151 COURSE INDICATOR — a combination Cross Pointer—Course Selector—Pictorial Heading—Ambiguity and Deviation Indicator. 2¾" dial opening.

Navigation instruments

Engine instruments

Power supply instruments

Communications instruments

Special purpose instruments

Test Equipment

WESTON Aircraft *Instruments*

Weston Electrical Instrument Corporation

614 Frelinghuysen Avenue, Newark 5, New Jersey

Why BREEZE MARK

JOB ENGINEERED BELLOWS

. . . outperform and outlast any other types

TYPICAL APPLICATIONS

Expansion Joints
Pressure Switches
Pressure Control Instruments
High Temperatures (Exhausts)
Low Temperatures (Liquid Gases)
Swivel Type Joints for High Pressure Steam Lines
Valve Seals
Packless Valves
Flow Control
Critical Thermostatic Uses

Where ordinary formed bellows fail, Breeze welded diaphragm bellows stand up under critical conditions for a long service life.

Their dependable performance is due to the fact that they are custom made for each individual application. This permits selection of the most satisfactory metal, the correct thickness, size and shape. Each job is engineered to meet or exceed specified requirements as to deflection, resistance to corrosion, vibration and high internal and external pressures. "Strength insurance" is welded in at inside and outside diameters. If you have a bellows problem, send for our Form B-100, on which you can conveniently submit your special requirements.

Sizes ⅜ to 10 inches inside diameter

OTHER BREEZE PRECISION PRODUCTS

Special Electrical Connectors
Electro-Mechanical and Hydraulic Actuators
Ignition Shielding
All Types of Flexible Metal Tubing
Aero-Seal Worm Drive Hose Clamps

BREEZE CORPORATIONS, INC.
41 South 6th Street, Newark 7, New Jersey

Zone. Charles A. Hughes. *U.S., CAA TDR 205*, June, 1953. 8 pp.

Determination of Means to Safeguard Aircraft from Power Plant Fires in Flight. V—The Lockheed Constitution (Navy XR60-1). Lyle E. Tarbell. *U.S., CAA TDR 198*, Apr., 1953. 43 pp.

The Fire Risks of Aircraft Factories. W. T. Good. *J. SLAE*, May, 1953, p. 3. Related to planning and development, manufacture and testing, and other aspects of production.

Flight Testing

Messverfahren Fur Instationare Flugbewegungen (A Test Method for Accelerated Flight Conditions). W. Liebe. *Gt. Brit., MOS GDC 10/1009T TIB T.3475* (Apr. 5, 1938), 1951. 33 pp. Translation. Method to record the time-histories of the forces and moments, as well as of the parameters controlling motion; evaluation of reliability of instrumentation.

Fuels & Lubricants

Analysis of Propellants by Infrared Spectroscopy. Frank Pristera. *Anal. Chem.*, June, 1953, p. 844. 24 refs. At the Picatinny Arsenal, Dover, N. J.; analysis includes 25 charts.

Binary Vapor-Liquid Equilibria; Trial and Error Prediction and Correlation. Arthur Rose, E. T. Williams, W. W. Sanders, R. L. Heiny, and J. F. Ryan. *Ind. & Eng. Chem.*, July, 1953, p. 1568. 26 refs. Study of thermodynamic relationships.

Combustion Chamber Deposits as Related to Carbon-Forming Properties of Motor Oils. J. D. Bartleson and E. C. Hughes. *Ind. & Eng. Chem.*, July, 1953, p. 1501. 22 refs.

Equilibrium Composition of Combustion Products of Leaded Octanes with Air. Edwin B. Cook, Robert W. Smith, Jr., and Stuart R. Brinkley, Jr. *U.S., Bur. Mines Rep. Invest. 4947*, Mar., 1953. 15 pp. Investigation of six octane mixtures at different pressures and temperatures.

Petroleum Fuels. Wheeler G. Lovell. *Ind. & Eng. Chem.*, July, 1953, p. 1426. Properties and requirements for spark and compression ignition engines and for turbines and jets.

Physical Properties of Concentrated Nitric Acid. W. L. Sibbitt, C. R. St. Clair, T. R. Bump, P. F. Pagerey, J. P. Kern, and D. W. Fyfe. *U.S., NACA TN 2970*, June, 1953. 19 pp. 32 refs. Investigation to obtain reliable values of thermal properties for use in heat-transfer and fluid-friction-characteristics research.

Present Problems and Future Trends in Lubrication. W. A. Zisman. *Ind. & Eng. Chem.*, July, 1953, p. 1406. 126 refs. Research survey on friction and wear prevention, special synthetic oils for aviation uses, rust inhibitors, viscosity index improvers, detergent oils, lubricating greases, and other factors.

Reaction Processes Leading to Spontaneous Ignition of Hydrocarbons. Charles E. Frank and Angus U. Blackham. *U.S., NACA TN 2958*, June, 1953. 27 pp. 14 refs.

dependable
fuel shut-off valves with high flow capacity

General Controls AV-16 Series Gate Valves are ideally suited for fuel transfer, fuel-to-engine flow control, refueling operations, and to regulate high volume aircraft oil, water, alcohol and coolant systems. Four types of interchangeable actuators assure the right valve for every application: motor-driven, manual, motor-driven with manual override, and splined shaft for cable or lever operation. Among their outstanding features: one-piece cast aluminum bodies; planetary reduction gearing; positive drive clutch; visual valve-position indicator. For full information about these soundly designed, industry approved Hi-g aircraft controls, send for your copy of General Controls catalog 53A today.

GENERAL CONTROLS

Glendale, California • Skokie, Illinois

Manufacturers of Automatic Pressure, Temperature, Level and Flow Controls for Heating, Home Appliances, Refrigeration, Industrial and Aircraft Applications.

FACTORY BRANCHES IN 35 PRINCIPAL CITIES

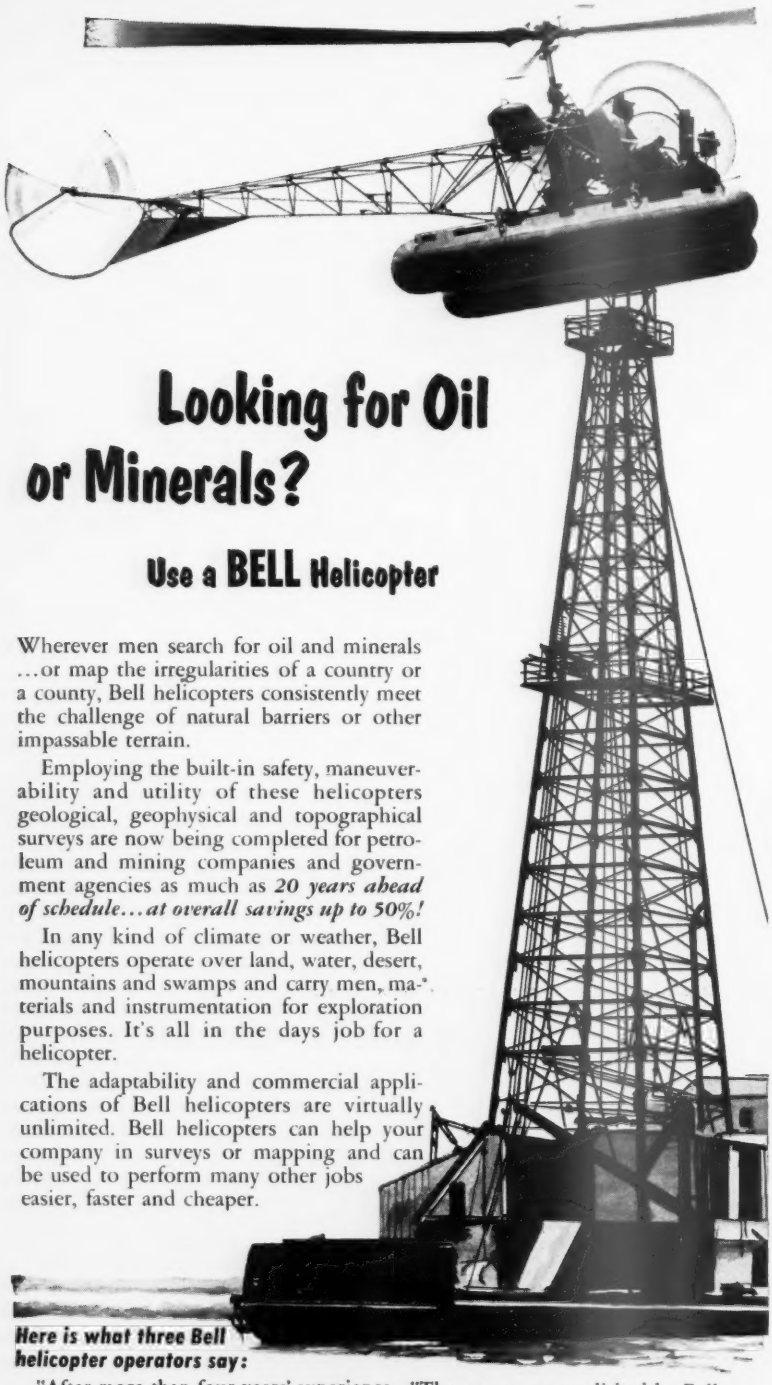
See your classified telephone directory

Above is one of the AV-16 series of super aircraft gate valves, the AV-16B straight on-and-off motor valve, available in seven tube sizes from ¾" to 4". Meets all standard and proposed AN specifications for handling standard fuels and gases. Available for 24v dc or 400 cycle ac systems. Operating pressure from 0 to 100 psi. Clutch limit control permits use of conventional motor with exact "on-off" positioning. Valve movement can be instantly reversed at mid-point.

General Controls

AV-16

hi-g gate valves



Looking for Oil or Minerals?

Use a BELL Helicopter

Wherever men search for oil and minerals ...or map the irregularities of a country or a county, Bell helicopters consistently meet the challenge of natural barriers or other impassable terrain.

Employing the built-in safety, maneuverability and utility of these helicopters geological, geophysical and topographical surveys are now being completed for petroleum and mining companies and government agencies as much as ***20 years ahead of schedule...at overall savings up to 50%!***

In any kind of climate or weather, Bell helicopters operate over land, water, desert, mountains and swamps and carry men, materials and instrumentation for exploration purposes. It's all in the days job for a helicopter.

The adaptability and commercial applications of Bell helicopters are virtually unlimited. Bell helicopters can help your company in surveys or mapping and can be used to perform many other jobs easier, faster and cheaper.

Here is what three Bell helicopter operators say:

"After more than four years' experience, we find the Bell helicopter the most satisfactory from the standpoint of cost maintenance and availability."—ROBERT L. SUGGS, President, Petroleum-Bell Helicopters, Inc., Lafayette, La.

"The survey accomplished by Bell helicopters in one summer would take 20 years by any other method."—JAMES S. RICKLEFS, Rick Helicopters, Inc., Los Angeles, California.

"Allied's Bell helicopters have done mapping and survey work intheRockies and Alaska at savings of 50% and more over other methods."—ROY B. DAVID, Allied Helicopter Service, Tulsa, Oklahoma.

BELL Aircraft CORPORATION

For Operational Information Write:

BELL AIRCRAFT CORPORATION

Texas Division

P. O. Box 482 Ft. Worth, Texas

Remarques sur les Calculs de Combustion. U. T. Boedewadt and R. Engel. *La Recherche Aéronautique*, Mar.-Apr., 1952, p. 19. In French. Calculations of combustion; analysis of initial conditions of Ergols, a synthetic benzine; description of a new procedure for the determination of the theoretical performance of Propergol.

Studi e Orientamenti nel Campo dei Combustibili e dei Lubrificanti Avio negli Stati Uniti (Studies and Trends for Aviation Fuels and Lubricants in the United States). Virgilio Ceccarini. *L'Aerotecnica*, Apr., 1953, p. 141. In Italian. Analysis of products in use at research centers.

Gliders

Aerodynamic Appraisal of the Fauvel AV-36. B. H. Carmichael. *Soaring*, July-Aug., 1953, p. 2.

High Flying on the Big Wave. Joachim P. Keuttner. *Soaring*, July-Aug., 1953, p. 35. Part II of the 1952 Tuntland Award-winning report of a sailplane flight "Over Death Valley, Skull Mountain and Funeral Peak."

The Slingsby Sky High-Performance Sailplane; A Successful British Design.... J. R. Reussner. *Aircraft Eng.*, June, 1953, p. 918, cutaway drawing.

Instruments

Anomalous Flow of Liquids Through Capillaries and Measurement of Viscosity. G. F. M. Calderwood, H. W. Douglas, and E. W. Mardles. *Anal. Chem.*, June, 1953, p. 935. RAE method and apparatus.

The Directional Gyroscope; A Discourse on "Gimballing Errors," Their Nature and Effects. P. Hobley. *J. SLAE*, May, 1953, p. 10.

The Motion Due to Slow Procession of a Gyroscope Driven and Supported by a Hooke's Joint. R. N. Arnold and L. Maunder. *IME Proc. (B), Appl. Mech.*, No. 3, 1952, p. 77; Communications, p. 89.

Note sur un Fréquencemètre Enregistreur pour Rayons X. J. Blin. *La Recherche Aéronautique*, Sept.-Oct., 1952, p. 29. In French. Description of a rapid-recording frequency meter used for X-ray measurement of aerodynamic airflow and other applications.

A Recurrent Sweep Chronograph for the Measurement of Small Time Intervals especially in Ballistics. Hilary Moss. *Electronic Eng.*, July, 1953, p. 282.

Operating Modes of a Servomechanism with Non-Linear Friction. Henri Lauer. *J. Franklin Inst.*, June, 1953, p. 497.

Servomechanisms; Controlling Vehicles in the Air. Preston R. Bassett. *Sperryscope*, Second Quarter, 1953, p. 20. Developmental survey.

Pressure-Measuring Devices

Design and Use of an Electronic Pressure Controller. F. J. Digney and Stephen Yerazunis. *Anal. Chem.*, June, 1953, p. 921. 13 refs. At Rensselaer Polytechnic Inst., Troy, N. Y.

High-Resolution Micromanometer; A Capacitance-Type Micromanometer for Measuring Very Low Differential Pressures. *U.S., NBS Sum. TR 1792*, July, 1953. 6 pp.

A Small Pirani Gage for Measurements of Nonsteady Low Pressures. M. John Pilny. *U.S., NACA TN 2946*, June, 1953. 36 pp.

Machine Elements

Graphical Linkage Analysis. R. A. Kraus and K. S. Rangasami. *Mach. Des.*, June, 1953, p. 177. A direct method for the design of four-bar linkages to perform specialized functions, such as that used in harmonic transformer layouts.

Investigation into Erosion of Gear Teeth. G. Niemann and H. Glaubitz. (*VDI-Zeitschrift*, Feb. 21, 1953, p. 164.) *Engr. Dig.*, June, 1953, p. 217.

Noise Investigation of Rolling Bearings. G. Lohmann. (*Konstruktion*, Nos. 2, 3, 1953, pp. 38; 85.) *Engr. Dig.*, June, 1953, p. 204. Test procedures and vibration-measuring equipment; generation of running noise; practical criteria for noise reduction.

Torsion of a Circular Shaft with Diameter Varying Periodically along its Length. Hajimu Ōkubo. *ZAMP*, May 15, 1953, p. 197.

Materials

An Analytical Theory of the Creep Deformation of Materials. Yoh-Han Pao and Joseph Marin. *J. Appl. Mech.*, June, 1953, p. 245. Theoretical formulation for an idealized material.

Behavior of Materials Under Conditions of Thermal Stress. S. S. Manson. *U.S., NACA TN 2933*, June, 1953. 105 pp. 22 refs. Review of available information on stress and strain behavior of brittle and ductile materials subjected to certain thermodynamic conditions.

Sandwich Construction and Core Materials. Part 6. I—"Balsolite" Impregnated Paper Cellular Material as an Elastic Stabiliser. W. J. Pullen. **II—Compression Tests on Sandwich Panels with "Balsolite" Cores.** R. G. Chapman and S. Pearson. **III—Strength Tests of a Typhoon Type Fuselage of "Balsolite" Sandwich Construction.** J. K. Oaks. *Gt. Brit., ARC R&M 2687* (Feb. 1948), 1952. 18 pp. BIS, New York. $1.25.

Corrosion & Protective Coatings

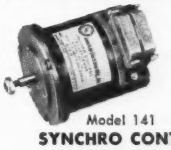
The Galvanic Corrosion Theory for Adherence of Porcelain-Enamel Ground Coats to Steel. D. G. Moore, J. W. Pitts, J. C. Richmond, and W. N. Harrison. *U.S., NACA TN 2935*, June, 1953. 19 pp. 11 refs.

Oxydation en Fonderie des Alliages Aluminium-Magnésium et Role Protecteur du Glucinium à Très Faibles Doses. J. Calvet and V. Potemkine. *La Recherche Aéronautique*, Sept.-Oct., 1952, p. 21. In French. Study of rapid oxidation in the foundry of aluminum-magnesium alloys and of the slow alteration of less-concentrated alloys with progressive appearance of magnesium; the corrosion-resistant role of glucinum; applications.

In large scale production NOW!

American Electronic

Model 140
SYNCHRO GENERATORS


Model 141
SYNCHRO CONTROL TRANSFORMERS

A pair with an established reputation. The heart of modern two-speed systems.

AVAILABLE FOR IMMEDIATE DELIVERY:

Size 15
UNIVERSAL-FREQUENCY PRECISION RESOLVER
Minimum noise, highest accuracy. Basic to all trigonometric operations.

Size 15
UNIVERSAL-FREQUENCY PRECISION POTENTIOMETER
Continuous rotation, induction type. Accuracy comparable to resolver.

Model 171
SERVO COMPUTING TACHOMETER
Companion to Model 172 Servomotor. Superior linearity and signal-to-noise ratio

Model 172
SERVO CONTROL MOTORS
"Standard" in many modern computers and controls. Thousands in use

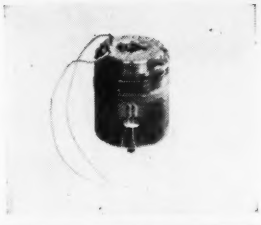
FEATURES
- Maximum accuracy, signal-to-noise ratio, range of linear operation.
- Minimum noise, size and friction.
- Total magnetic shielding.
- Internal winding or external network compensation.
- High temperature resistant models.
- Corrosion and fungus resistant.
- Complete line of "packaged" compensating isolation driver-amplifiers.
- Reliable delivery commitments.

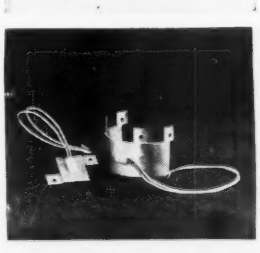
READY FOR FALL DELIVERY:
Sizes 11 and 23 Induction Resolvers and Potentiometers · Sizes 11 and 15 Servo Control Motors and Computing Tachometers · Model 293 Brushless Potentiometers.

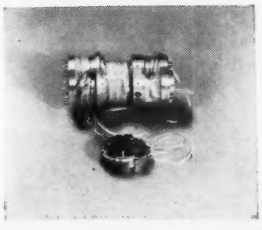
ae

American Electronic Mfg., Inc.
9503 W. Jefferson Blvd., Culver City, Calif.

NEW! Low Temperature HEATING ELEMENTS by COX







Can be permanently cemented in place on curved or flat surfaces

- Applies Heat "On the Spot"
- Temperature of Heating Element is Only Slightly Higher than Object Being Heated
- High or Low Rating per Unit Area
- Available as Wire or Flexible Sheets
- Ultra-safe—Minimum Current Requirement

Cox Heating Elements are *new* and *completely different;* When cemented in position, the elements stay in place regardless of temperature change or mechanical shock. Used by leading manufacturers, they have already proved their worth in more than 200 military applications for guided missiles, Airborne Instruments, Hydraulic Equipment, Batteries, etc.

Solve your equipment heating problems now with Cox Heating Elements.

Write for Data

COX & COMPANY, Inc.
115 East 23rd St., New York 10, N. Y.

Radiation Suppressing Coatings for Metals at Elevated Temperatures. A. H. Sully, E. A. Brandes, and R. B. Waterhouse. *Fulmer Res. Inst. Spec. Rep. 1*, Apr., 1953. 24 pp. Development of a refractory coating of low thermal emissivity to be applied to alloys in gas-turbine construction to withstand operating conditions involving thermal shock and vibration.

Metals & Alloys

A Dictionary of Metallurgy. XVII—Go-Ha. A. D. Merriman and J. S. Bowden. *Metal Treatment*, June, 1953, p. 273.

Fundamentals of Bimetal Performance. *AIEE Appliance Tech. Conf., Louisville, Ky., Apr. 22-24, 1953, Paper.* 8 pp. Properties and applications of thermostatic bonded metals.

Metal Fatigue—What It Is. P. L. Teed. *Flight Safety Foundation Mech. Bul.*, May-June, 1953, p. 4.

On the Temperature Sensitivity of Special Magnetic Materials. T. A. Heddle. *Brit. J. Appl. Phys.*, June, 1953, p. 161. 40 refs.

Why Metals are Weak. J. C. Fisher. *G-E Rev.*, July, 1953, p. 15. Crystal structure and plastic deformation.

Metals & Alloys, Ferrous

Deformation Twinning in Charpy V-Notch Specimens of Ingot Iron. G. W. Geil and N. L. Carwile. *Welding J., Welding Res. Suppl.* Sect., June, 1953, p. 273-s.

High Strength Precision Iron Powder Parts. William J. Doelker and Harold T. Harrison. *Materials & Methods*, July, 1953, p. 67. Properties and specifications for use; finishing; applications.

The Origin of Damping in High-Strength Ferromagnetic Alloys. A. W. Cochardt. *J. Appl. Mech.*, June, 1953, p. 196. 14 refs.

Structural Applications of Stainless Steel. I., II. A. G. Dean. *The Engr.*, June 19, 26, 1953, pp. 853; 882. For airframes, components, jet engine construction, and other applications; stress and strain analysis; mechanical limitations.

Metals & Alloys, Nonferrous

Grossissement des Grains sans Déformation Préalable par Chauffage de Pièces Coulées en Alliage Al-Mg de Haute Pureté. J. Calvet, Charlotte Buckle, and Christiane Changarnier. *La Recherche Aéronautique*, Mar.-Apr., 1952, p. 47. In French. Experimental study of the increase of grain and the expansion of crystals in aluminum-magnesium alloys of high purity subjected to various conditions and temperatures.

The Specific Heat of Beryllium at Low Temperatures. R. W. Hill and P. L. Smith. *Philos. Mag.*, June, 1953, p. 636. 13 refs. Study of thermodynamic properties and functions for electronic measurements and other applications.

The Thermal and Electrical Conductivities of Beryllium. R. W. Powell. *Philos. Mag.*, June, 1953, p. 645. 21 refs. NPL research.

Analytical Chemistry of Niobium and Tantalum; Simultaneous Spectrophometric Determination of Tantalum and Niobium. F. C. Palilla, Norman Adler, and C. F. Hiskey. *Anal. Chem.*, June, 1953, p. 926. 22 refs.

The Manufacture and Properties of Titanium and Its Alloys. I. N. P. Allen. *Metal Treatment*, June, 1953, p. 245. American and European developments; details of NPL research.

On the Welding of Titanium Alloys. C. B. Voldrich. *Welding J.*, June, 1953, p. 497. The 1952 Adams Lecture on properties, potentialities, and welding characteristics, with a description of applicable processes.

Surface Contamination and Quality in Titanium Fabrication. V. C. Petersen. *Materials & Methods*, July, 1953, p. 72. Properties; procedures for cold-forming; other aspects.

The Creep of Zinc Single Crystals under Direct Shear. Elliot H. Weinberg. *J. Appl. Phys.*, June, 1953, p. 734. 26 refs.

Nonmetallic Materials

Effects of High Degrees of Biaxial Stretch-Forming on Crazing and Other Properties of Acrylic Plastic Glazing. I. Wolock, B. M. Axilrod, and M. A. Sherman. *U.S., NACA RM 53D14*, May 29, 1953. 18 pp.

An Ethoxylene Resin for Photoelastic Work. H. Spooner and L. D. McConnell. *Brit. J. Appl. Phys.*, June, 1953, p. 181. Araldite casting resin type B; properties; application to stress analysis; development of practical photoelastic techniques.

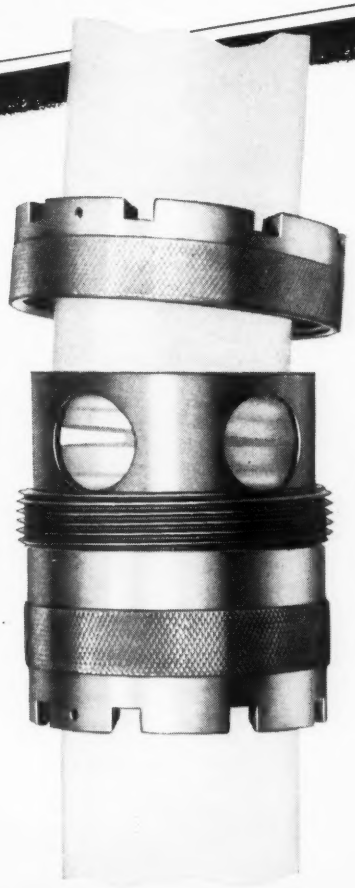
ANNOUNCING

WIGGINS **WIG-O-FLEX** COUPLINGS

for connecting rigid tubes

PROVED SUPERIOR FOR FUEL, OIL, AIR

- 80% lighter • Installs locally
- Requires little more than hand tightening
- Accommodates 1/4" tube length variations
- Accommodates 1/16" tube misalignment
- Accommodates 4° tube flexure
- Requires only standard parts—"O" rings and tube beads
- Temperature range—65° F. to +250° F.
- Withstands more than 1,000 PSI burst pressure



SIZES

1", 1¼", 1½", 1¾", 2", 2½", 3", 3½", 4"

OTHER COUPLINGS ALSO AVAILABLE
for all liquids and gases

SELF-SEALING AND OPEN COUPLINGS
MANUAL AND AUTOMATIC OPERATION
HIGH PRESSURE — 3000 PSI
LOW PRESSURE — 1000 PSI

Write for further information

Wiggins

E. B. WIGGINS OIL TOOL COMPANY, INC.
3424 East Olympic Boulevard, Los Angeles 23, California

REPRESENTATIVES: AERO ENGINEERING, INC.: AKRON • BALTIMORE • INDIANAPOLIS • MINEOLA, N. Y. • AERO SALES ENGINEERING, LTD.: MONTREAL, CANADA • AIR SUPPLY CO.: LOS ANGELES • FT. WORTH • KANSAS CITY • SEATTLE • TULSA • WICHITA • G. R. CARRIER: CHICAGO • JAMES H. CONNELL: MILWAUKEE • CHARLES T. MORGAN: BEVERLY, MASS. • HARVEY PIPE: DAYTON • F. W. SMITH: CLEVELAND • EDWARD WOLTEMATE: PHILADELPHIA

How to Tell Quality in Teflon. I. D. Press. *Materials & Methods*, July, 1953, p. 64. Porosity defects; electrical and other properties; testing methods.

Reinforced Plastics. I—Asbestos-Fibre Materials. D. S. Bancroft. **II—Glass-Fibre Materials.** G. C. Hulbert. *Aircraft Prod.*, July, 1953, pp. 262; 265. Structural airframe applications.

Recherches sur la Relation Contrainte-Biréfringence dans le Plexiglas M 222 (Research on Double-Refractive Strain Relations in Plexiglass M 222). J. Aubaud. *La Recherche Aéronautique*, Mar.-Apr., 1952, p. 31. In French. The optical and mechanical creep of plexiglass M 222 used in photo-elastic measurements to determine the natural elasticity in traction and compression of double refraction.

Stratifié à Base Papier Stratifié Papier-Melamine. Pierre Lutz. *La Recherche Aéronautique*, July-Aug., 1952, p. 53. In French. Physical and mechanical properties of a new material based on paper and melamine-resin combination; determination of conditions for production.

Dynamic Mechanical Properties of the System Polystyrene-Decalin. Lester D. Grandine and John D. Ferry. *J. Appl. Phys.*, June, 1953, p. 679. 22 refs.

Materials & Methods Manual No. 95: Rubber Parts. Philip O'Keefe. *Materials & Methods*, July, 1953, p. 85. Comparative properties of rubber compositions; physical property ranges of typical heat-resistant and other compounds; other characteristics; fabrication tolerances and design requirements; applications.

Mechanical Investigations of Elastomers in a Wide Range of Frequencies. Wladimir Philippoff. *J. Appl. Phys.*, June, 1953, p. 685.

A New Technique for the Mass Spectrometric Study of the Pyrolysis Products of Polystyrene. Paul Bradt, Vernon H. Dibeler, and Fred L. Mohler. (*U.S., NBS Res. Paper 2410.*) *U.S., NBS J. Res.*, Apr., 1953, p. 201.

A Test of the Theory of Secondary Viscoelastic Stress. M. Mooney. *J. Appl. Phys.*, June, 1953, p. 675.

Viscoelastic Properties of Dilute Polymer Solutions. P. E. Rouse, Jr., and K. Sittel. *J. Appl. Phys.*, June, 1953, p. 690. 27 refs. Measurements in the frequency range from 200 cycles per sec. to 60 kc.

Testing

L'Analyse Microspectrographique des Métaux et Alliages. J. Descamps. *La Recherche Aéronautique*, Mar.-Apr., 1953, p. 39. 31 refs. In French. Simple and rapid microspectrographic method for the study of metals and alloys; applications.

Direct Examination of Solid Surfaces Using a Commercial Electron Microscope in Reflection. J. W. Menter. *J. Inst. Metals*, 1952–53, p. 163. 14 refs. Reprint.

An Improved Scanning Electron Microscope for Opaque Specimens. D. McMullan. (*IEE Measurements Sect. Paper 1381.*) *Proc. IEE*, Part II, June, 1953, p. 245; Discussion, p. 257. For examination of surfaces and structure of aluminum, zinc tungsten, and other metals.

La Méthode de Transfert sur Contre-Électrode et son Application au Dosage Spectrographique des Hautes Teneurs. F. Malamand. *La Recherche Aéronautique*, Mar.-Apr., 1953, p. 51. In French. Electronic transfer method related to the quantitative spectrographic analysis of cobalt-chrome, iron-chrome, nickel-chrome, iron-nickel, and chrome-nickel-steel alloys of high purity.

Techniques for the Electron Microscopy of Crystals. I. M. Dawson. *Brit. J. Appl. Phys.*, June, 1953, p. 177. 20 refs. Application to structural studies of various types of materials.

Mathematics

Contributions to the Theory of Markov Chains. Kai Lai Chung. (*U.S., NBS Res. Paper 2411.*) *U.S., NBS J. Res.*, Apr., 1953, p. 203. 10 refs.

The Method of Influence Factors in Arithmetical Solutions of Certain Field Problems. I, II. A. Thom and Laura Klanfer. *Gt. Brit., ARC R&M 2440 (Aug., 1946)*, 1953. 30 pp. BIS, New York. $1.80. Extension to the "squares" method.

Le Point de Vue du Physicien dans le Problème du Lissage des Courbes Expérimentales. Pierre Vernotte. *France, Min. de l'Air NT 46*, 1953. 24 pp. In French. The physicist's viewpoint in opposition to that of the mathematician in experimental research problems involving the smoothing out of mathematical curves.

Problèmes Elliptiques et Hyperboliques Singuliers pour une Équation du Type Mixte. P. Germain and R. Bader. *France, ONERA Pub. 60*, 1952. 42 pp. In French. Study of elliptic and hyperbolic problems for a mixed equation of the form

$$k(\sigma)\,\frac{\partial^2\psi}{\partial O^2}+\frac{\partial^2\psi}{\partial\sigma^2}=O$$

The Relaxation Treatment of Singular Points in Poisson's Equation. L. C. Woods. *Quart. J. Mech. & Appl. Math.*, June, 1953, p. 163. 13 refs. NPL method applicable to computers using the relaxation technique.

Uniqueness in Cauchy Problems for Elliptic Systems of Equations. Avron Douglis. *Commun. on Pure & Appl. Math.*, May, 1953, p. 291.

Eigenfunction Expansions Associated with Partial Differential Equations. II. E. C. Titchmarsh. *Proc. London Math. Soc., 3rd Ser.*, Mar., 1953, p. 80. 12 refs.

Nonlinear Hyperbolic Equations. Peter D. Lax. *Commun. on Pure & Appl. Math.*, May, 1953, p. 231. 18 refs. Extension of Cauchy-Kowalewski theorem for partial differential equations; application to solutions of nonanalytic initial value and other problems.

On Self-Adjoint Differential Equations of Second Order. Ruth Lind Potter. *Pacific J. Math.*, June, 1953, p. 467.

A Function-Theoretic Approach to Elliptic Systems of Equations in Two Variables. Avron Douglis. *Commun. on Pure & Appl. Math.*, May, 1953, p. 259. ONR-sponsored research at CIT.

Length and Area of a Convex Curve Under Affine Transformation. John W. Green. *Pacific J. Math.*, June, 1953, p. 393.

On Generation of Solutions of the Biharmonic Equation in the Plane by Conformal Mappings. Charles Loewner. *Pacific J. Math.*, June, 1953, p. 417.

Some Coordinate Systems Associated with Elliptic Functions. Parry Moon and Domina Eberle Spencer. *J. Franklin Inst.*, June, 1953, p. 531. 19 refs. Results of a study of cylindrical and rotational coordinate systems based on elliptic-function transformations.

Subfunctions of Several Variables. E. F. Beckenbach and L. K. Jackson. *Pacific J. Math.*, June, 1953, p. 291. A generalization of subharmonic functions.

Meteorology

The Dynamics of a Vortex Embedded in a Constant Zonal Current. Sadayoshi Tojo. *J. Meteorology*, June, 1953, p. 175.

Forecasting the Speed of Movement of Selected Cyclones Along Upper-Air Steering Channels. Ernest M. Rampey. *J. Meteorology*, June, 1953, p. 191.

The Variation with Height of the Vertical Flux of Heat and Momentum. Harrison E. Cramer and Frank A. Record. *J. Meteorology*, June, 1953, p. 219. 19 refs. USAF-sponsored MIT atmospheric turbulence research in the 2-to-12 meter layer.

Military Aviation

Recent Developments in the Navy's Air Arm. J. N. Murphy. *Aero. Eng. Rev.*, Aug., 1953, p. 24. Discussion on water-based aircraft, airships, and the canted-deck concept in terms of design safety; psychological, operational, and other factors.

Missiles

The Drag of Finite-Length Cylinders Determined from Flight Tests at High Reynolds Numbers for a Mach Number Range from 0.5 to 1.3. Clement J. Welsh. *U.S., NACA TN 2941*, June, 1953. 12 pp.

Guided Missile Tests in 20 Seconds. T. L. Greenwood. *Instrumentation*, Second Quarter, 1953, p. 12. Research facilities and equipment at Army Ordnance Missile Labs, Huntsville, Ala.

How Electronics Controls Guided Missiles. John M. Carroll. *Electronics*, July, 1953, p. 130. Aerodynamic control and flight history of V-2 and other rockets.

Recent Developments in Foreign Rockets and Guided Missiles. Norman J. Bowman. *J. Space Flight*, June, 1953, p. 1. Includes tabulated data on foreign rocket types.

Ordnance & Armament

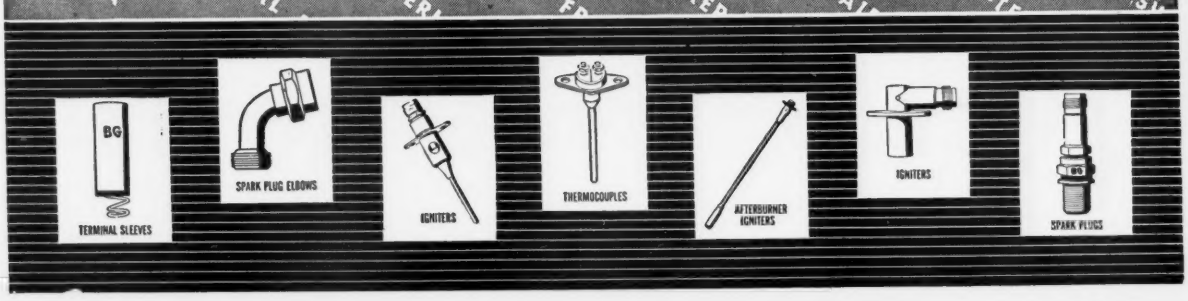
New Ordnance Development Facilities at NBS; Specialized Equipment for Study of Effects of High Acceleration on Experimental Ordnance Components. *U.S., NBS Sum. TR 1771*, July, 1953. 6 pp.

Quality by BG

Proof of the superior quality of BG Aircraft Spark Plugs is their use wherever quality products are a must. Choice of leading airlines the world over, BG Aircraft Spark Plugs are symbolic of 35 years of specialized experience in the design and manufacture of aviation products.

For information on this and other BG products write to

THE BG CORPORATION
136 West 52nd Street
New York 19, N. Y.



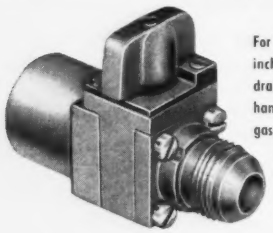
WITTEK

Aviation
HOSE CLAMPS

Standard of the Industry for Over a Quarter Century

WITTEK
Manufacturing Co.
4305-15 West 24th Place
Chicago 23, Illinois
4447

Before you specify
Check KOEHLER
BALL DRAIN VALVES



For ¼, ⅜ and ½ inch OD tube in drain systems handling fuels, gases, oils, water-alcohol and corrosive fluids.

Koehler Ball Drain Valves are small, light, yet simply constructed and rugged. They meet USAF Specification No. 28208 and drawing No. 49F9798 performance and installation requirements. May be used at pressures up to 100 PSI; with Teflon seals, up to 500 PSI. Also available in large sizes for ⅝, ¾ and 1 inch OD tubes. Write for catalogue or send specifications.

KOEHLER
Aircraft Products Co., Inc.
814 Vermont Ave., Dayton 4, Ohio
Representatives: Western Aircraft Supply Co.; C & H Supply Co.; Prenco Progress & Eng. Corp., Ltd.

Photography

A Portable High Speed Stroboscope. A. E. Ferguson. *Elec. Eng.*, June, 1953, p. 252. Possible use as a light source in high-speed photography permitting up to 500 flashes per sec.

Physics

Formative Time Lags in the Electrical Breakdown of Gases. J. Dutton, F. Llewellyn Jones, and P. M. Davidson. *Brit. J. Appl. Phys.*, June, 1953, p. 170. 25 refs.

Kleine Schwingungen dynamischer Systeme. Paul Erdős. *ZAMP*, May 15, 1953, p. 215. In German. Solution of the Hamiltonian differential equations for small displacements of a dynamic system with a finite number of degrees of freedom by use of linear algebraic methods; demonstration of the stability of the equilibrium configuration or uniform motion.

The Quantum Mechanics of Collisions Between Rigid Axially Symmetric Molecules. George Gioumousis and C. F. Curtiss. *U. Wis. NRL Dept. Chem. Rep. 00R-8*, June 10, 1953. 21 pp.

Second Virial Coefficients of Gases Obeying a Modified Buckingham (Exp-Six) Potential. William E. Rice and Joseph O. Hirschfelder. *U. Wis. NRL Dept. Chem. Rep. ONR-2*, June 22, 1953. 17 pp.

Separation of Gases by Free Double Diffusion. F. A. Schwertz. *Ind. & Eng. Chem.*, July, 1953, p. 1592.

Transport Properties of Gases Obeying a Modified Buckingham (Exp-Six) Potential. Edward A. Mason. *U. Wis. NRL Dept. Chem. Rep. ONR-1*, June 19, 1953. 63 pp. 37 refs.

Virial Coefficients and Models of Molecules in Gases. Taro Kihara. *U. Wis. NRL Dept. Chem. Rep. 00R-7*, June 5, 1953. 49 pp. 23 refs.

Power Plants

New Data on Automotive Combustion. *U.S., NBS Sum. TR 1802*, July, 1953. 5 pp. NBS investigations on engine compression and hydrocarbon and other fuels.

The Internal Reaction Engine. J. R. Goodykoontz. *J. ASNE*, Feb., 1953, p. 97. Reprint. Fundamental principles; theoretical possibilities for space travel.

Étude de la Structure d'un Jet d'Injecteur de Turboréacteur par une Méthode de Captation. G. Dubois, R. Kling, and R. Jean. *La Recherche Aéronautique*, July-Aug., 1952, p. 31. In French. Combustion studies; use of a thin wire network to obtain fog-sample for application in turbojet injectors; analysis of the wiresond captation method.

An Investigation into the Pitot Rake Method of Measuring Turbo Jet Engine Thrust in Flight. J. Stephenson, R. T. Shields, and D. W. Bottle. *Gt. Brit., AAEE Rep. Res/265*, Dec. 23, 1952. 57 pp., folded charts.

The SNECMA Escopette Pulse-Jet. J. Bertin and J. Le Foll. *Interavia*, No. 6, 1953, p. 343. Design and development;

Aetco
UNUSUAL SPECIALIZED TESTS

Some of the unique, highly specialized equipment tests which AETCO is set up to perform promptly:

1. Fungus effects
2. Sand and dust effects
3. Salt spray effect
4. Complete DC Electrical System tests
5. High frequency 400 cycle AC Equipment tests

General aircraft component testing, including hydraulic, pneumatic, electrical (400 cycle AC-DC) and mechanical

In-flight testing to!

Aetco
1806-12 FLEET ST.
BALTIMORE 31, MD.
AIRCRAFT EQUIPMENT TESTING COMPANY

AIRSURANCE
Airline Passenger Insurance
Annual Policies
from $5,000 to $100,000
at new low rates
No Physical Examination • No Age Limit

EXAMPLE
$25,000.00 for death or dismemberment
$1,000.00 for Hospital and Doctor's bills
$50.00 per week when disabled
PREMIUM $38.00 per year

Policies cover passengers on scheduled airlines WORLD-WIDE

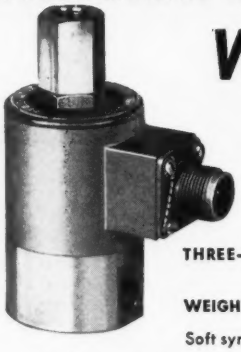
Write or phone your Insurance Agent

Backed by the Combined Assets of
Aetna Casualty & Surety Co.
American Employers' Insurance Co.
American Surety Co. of N. Y.
Century Indemnity Company
The Employers' Liability Assurance Corp., Ltd.
Hartford Accident & Indemnity Co.
Maryland Casualty Co.
Massachusetts Bonding & Insurance Co.
New Amsterdam Casualty Co.
Standard Accident Insurance Co.
Travelers Insurance Co.
United States Casualty Co.
United States Fidelity & Guaranty Co.

U.S. GROUP

UNITED STATES AVIATION UNDERWRITERS
INCORPORATED
80 JOHN ST. • NEW YORK 38, N. Y.
ATLANTA · CHICAGO · DALLAS · KANSAS CITY
LOS ANGELES · SAN FRANCISCO

AIRCRAFT APPROVED



V5 Solenoid STAINLESS STEEL Valves

THREE-WAY NORMALLY OPEN AND NORMALLY CLOSED

WEIGHT ONLY 1¼ LBS. APPROX. 3½" HIGH

Soft synthetic rubber inserts in plunger prevent leakage...Spring loaded for positive action...Power consumption approx. 10 watts...Usable in any position...Operating pressure to 150 P.S.I....Fluid connections to suit your specifications.

Some models for aircraft, such as valve illustrated, have Yellow Dot approval. Other solenoid aircraft valves available and under development for pressures to 3,000 P.S.I.

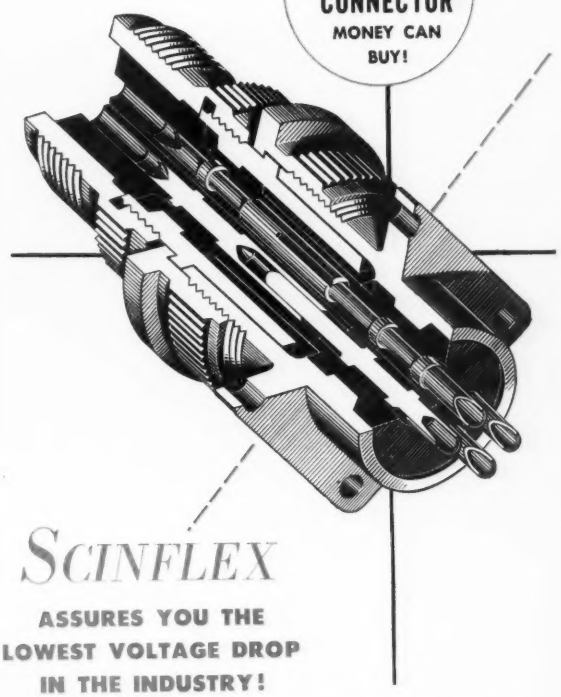
Two-way normally open and normally closed solenoid valves for special media such as liquid oxygen, nitric acid and concentrated hydrogen peroxide are also available in a variety of sizes.

Inquiries regarding your solenoid valve problems are welcomed.

SKINNER ELECTRIC VALVES

Skinner ELECTRIC VALVE DIV.
THE SKINNER CHUCK COMPANY
104 Edgewood Ave., New Britain, Conn.

The Finest **ELECTRICAL CONNECTOR MONEY CAN BUY!**



SCINFLEX

ASSURES YOU THE LOWEST VOLTAGE DROP IN THE INDUSTRY!

When operating conditions demand an electrical connector that will stand up under the most rugged requirements, always choose Bendix Scinflex Electrical Connectors. The insert material, an exclusive Bendix development, is one of our contributions to the electrical connector industry. The dielectric strength remains well above requirements within the temperature range of −67°F to +275°F. It makes possible a design increasing resistance to flashover and creepage. It withstands maximum conditions of current and voltage without breakdown. But that is only part of the story. It's also the reason why they are vibration-proof and moisture-proof. So, naturally, it pays to specify Bendix Scinflex Connectors and get this extra protection. Our sales department will be glad to furnish complete information on request.

• Moisture-Proof • Radio Quiet • Single Piece Inserts • Vibration-Proof • Light Weight • High Insulation Resistance • High Resistance to Fuels and Oils • Fungus Resistant • Easy Assembly and Disassembly • Fewer Parts than any other Connector • No additional solder required.

BENDIX SCINFLEX
ELECTRICAL CONNECTORS

Bendix

SCINTILLA MAGNETO DIVISION of SIDNEY, NEW YORK

Bendix AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

FACTORY BRANCH OFFICES: 118 E. Providencia Ave., Burbank, Calif. • Stephenson Bldg., 6560 Cass Ave., Detroit 2, Michigan • Brouwer Bldg., 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • 582 Market Street, San Francisco 4, California

A COMPLETE MEDIA PACKAGE FOR YOUR *Aviation Marketing Program*

AERONAUTICAL ENGINEERING REVIEW

For your monthly advertising message to the aircraft industry's engineering and design personnel—the men who influence buying.

1953 AVIATION MARKET GUIDE

Now Available!

24 pages of FACTS on your market and REVIEW.

Write for free copy TODAY!

AERONAUTICAL ENGINEERING CATALOG

Prefiles and distributes your aircraft products catalog to aviation's buyers and specifiers.

7,000 copies are distributed annually to aircraft engineers, designers, technicians and purchasing agents in all leading aircraft, engine and parts companies, Government aviation departments and leading air lines.

Write for your free copy of 12-page MARKET BOOK giving full details.

OFFICIAL PUBLICATIONS
INSTITUTE OF THE AERONAUTICAL SCIENCES
2 East 64th Street New York 21, N. Y.

operational requirements and functioning; application to gliders and other aircraft.

A Constant-Area, Constant-Temperature Combustor. Philip Rosen and R. W. Hart. *J. Aero Sci.*, Aug., 1953, p. 549. Theoretical analysis of ram-jet combustion factors.

Nuclear Energy and Rocket Propulsion. A. V. Cleaver. *The Aeroplane*, June 5, 1953, p. 736. Long-range planning, design, and potentialities.

Production

A Conspectus of French Aircraft. Derek H. Wood. *Aeronautics*, July, 1953, p. 38. Organizational survey of the French aero industry, including achievements and descriptions of different types of aircraft and engines.

France's Aircraft Industry Comes of Age. Pierre M. Gallois. *Interavia*, No. 6, 1953, p. 314. Evolution of French design and production, including output of turbojet and rotary-wing aircraft.

La SNCASO au Service de l'Aviation Française (The SNCASO and French Aviation). *SNCASO Brochure*, May, 1953. 22 pp. Survey of the French aviation industry, including coverage on research and prototypes, jet helicopters, and general aspects of production.

Moulded Glider Wing; Moulding Technique in the Manufacture of a Large Phenolic-Asbestos Component. Richard Wood. *Aircraft Prod.*, July, 1953, p. 234.

Quality Control of Resistance Welding by Statistical Methods. J. F. Radford and R. K. Waldvogel. *Welding J.*, June, 1953, p. 521. 17 refs.

Special Saws Used for Trimming Aircraft Parts. Raymond Kautz. *Auto. Ind.*, June 15, 1953, p. 32. Developed at Glenn L. Martin Co. for contouring wing-edges and honeycomb materials and other purposes.

Metalworking

Analysis of Maximum Temperatures in Workpieces. A. O. Schmidt. *Tool Engr.*, July, 1953, p. 53. Heat flow, friction, temperature distribution, and other problems in metal-cutting.

Electropolishing; Its Influence on the Fatigue-Endurance Limit of Ferrous and Non-Ferrous Parts. A. T. Steer, J. K. Wilson, and O. Wright. *Aircraft Prod.*, July, 1953, p. 242.

New Forming Process Reduces Vibration and Tooling Costs. Thomas A. Dickinson. *Steel Processing*, June, 1953, p. 283. The Formall process, developed by Engle Aircraft Specialties, Escondido, Calif.

Planning Reduces Forging Costs; Less Wastage of Metal by Study of Forging Methods. F. Emanuel. *Metal Treatment*, June, 1953, p. 253.

The Junghans' Method of Continuous Casting of Steel; Experimental Work at Mannesmann-Hüttenwerke A.G., Huckingen, Germany. II. K. G. Speith and A. Bungeroth. *Metal Treatment*, June, 1953, p. 268.

Predicting Casting Costs—with Accurate Design Yardsticks. Philip Tripoli. *Mach. Des.*, June, 1953, p. 139.

How Section Size Influences Strength Properties of Sand Castings. W. J. Reichenecker. *Materials & Methods*, July, 1953, p. 80.

Controlled Thermal Severity Cracking Test Simulates Practical Welded Joints. C. L. M. Cottrell. *Welding J., Welding Res. Suppl.* Sect., June, 1953, p. 257-s.

Effect of Atmospheric Contaminants on Arc Weld in Titanium. J. C. Barrett, I. R. Lane, Jr., and R. W. Huber. *Welding J., Welding Res. Suppl.* Sect., June, 1953, p. 283-s.

To What Extent Does Stress Relieving Occur at 200–300°C.? R. Gunnert. *Welding J., Welding Res. Suppl.* Sect., June, 1953, p. 292-s.

Ultrasonics—The Answer to Aluminum Soldering? Leo Walter. *Materials & Methods*, July, 1953, p. 59. Procedure; equipment to generate mechanical vibrations; applications.

Propellers

Propeller-Noise Charts for Transport Airplanes. Harvey H. Hubbard. *U.S., NACA TN 2968*, June, 1953. 47 pp. 11 refs.

Wake Survey and Strain-Gauge Measurements on an Inclined Propeller in the R.A.E. 24-ft Tunnel. I—Wake Survey. J. G. Russel. *Gt. Brit., ARC CP 117* (Feb., 1952), 1953. 60 pp. BIS, New York. $2.00.

Reference Works

Buyers' Guide Issue. *Electronics*, June Mid-Month, 1953. 912 pp. 27 refs. Reference Sheet Sect. includes graphical short-cuts for engineers in 36 articles; the Directory Sect. covers an alphabetical listing of products, registered trade names, an index of manufacturers, and names of distributors of electronic components and equipment.

Tele-Tech's Electronic Industries Directory, 1953. *Tele-Tech*, June, 1953, p. 195. Indexes cover: products and manufacturers, brands and trade names, advertisers distributors and firm representatives, and engineering consultants and societies.

Rotating Wing Aircraft

Calculation of the Induced Velocity Field of a Rotor. K. W. Mangler. *Gt. Brit., RAE Rep. Aero. 2247*, Feb., 1948. 68 pp.

The Low Speed Performance of a Helicopter. A. L. Oliver. *Gt. Brit., ARC CP 122* (May 15, 1952), 1953. 12 pp. BIS, New York. $0.65.

Some Thoughts on the Operational Future of the Transport Helicopter. Peter G. Masefield. *J. Helicopter Assn. Gt. Brit.*, Jan.-Feb.-Mar., 1953, p. 77; Discussion, p. 106. Complete text of lecture; discussion includes a symposium ("Brains Trust," p. 116) on rotary-wing problems.

Theory and Practice of Gas Turbine Power Plants for Helicopters. I, II. Igor B. Bensen. *Am. Helicopter*, May, June, 1953, pp. 6; 10. Rotor load requirements; speed regulation; torque demand; altitude and temperature performance; transient loads; properties of actual engine installations with an evaluation of distinctive features and performance.

Stability & Control

Automatic Control and Stabilization of Helicopters. L. S. Guarino. *AHS Mid-Eastern Regional Dinner Meeting, Philadephia, Pa., Feb.19, 1953, Paper.* 4 pp.

Design Considerations in the Kaman Servo-Controlled Intermeshing-Rotor Helicopter. Charles H. Kaman. *AHS New England Regional Meeting, Windsor Locks, Conn., Feb. 9, 1953, Paper.* 6 pp.

Maneuver Loads and Effect of Rapid Control Movement on a Model 47 Helicopter. W. O. Wettengel. *AHS Ninth Annual Forum, Washington, D. C., May 14, 15, 1953, Paper.* 23 pp.

Space Travel

I Fondamenti dell'Astronautica. (On the Fundamentals of Astronautics). G. Arturo Crocco. *L'Aerotecnica*, Apr., 1953, p. 135. In Italian. The universal gravitation rule and rocket propulsion; use of transfer ellipses and orbital refuelling; a new method of multistage missile design in which different stages are associated in parallel rather than in series and are recoverable.

Structures

Effect of Damping Constants and Stress Distribution on the Resonance Response of Members. B. J. Lazan. *J. Appl. Mech.*, June, 1953, p. 201. Analysis of factors governing the relationship of the external force which excites a vibration to the internal resonance excited force.

Graphical Shear and Moment Calculations. William S. Beller. *Aero Dig.*, June, 1953, p. 21. Simplified stress analysis method, with a mathematical justification for use.

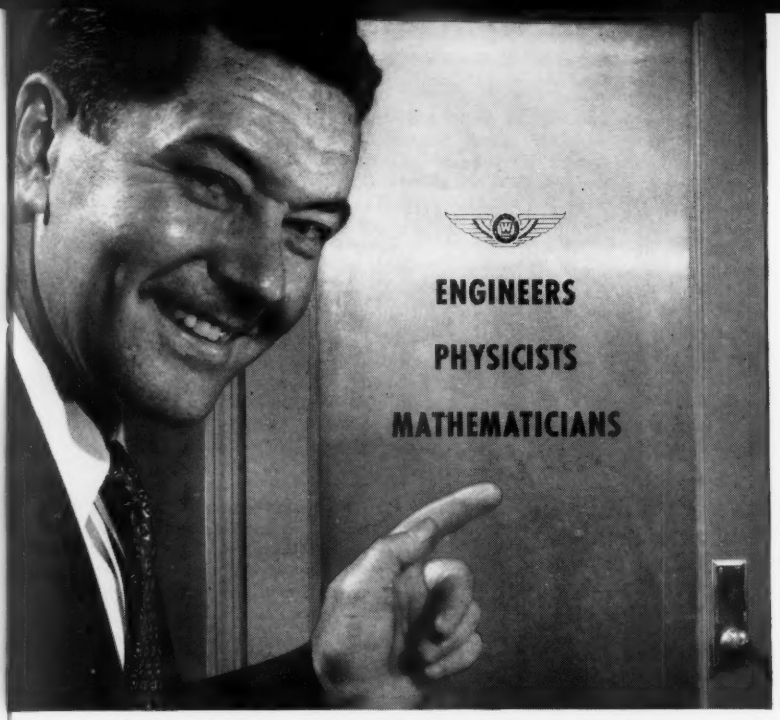
Indicateur du Centre de Gravité des Avions au Sol. J. Laxague. *La Recherche Aéronautique*, Sept.-Oct., 1952, p. 59. In French. Ground apparatus to determine the center of gravity of aircraft structure for loading purposes.

Preliminary Investigations of Strength Characteristics of Structural Elements at Elevated Temperatures. Eldon E. Mathauser and Charles Libove. *U.S., NACA RM L53E04a*, June 10, 1953. 12 pp.

Bars & Rods

Effect of Mean Stress on the Fatigue Strength of D.T.D.364 Round Bars with and Without Transverse Holes. G. M. Norris. *Gt. Brit., ARC CP 120* (May, 1952), 1953. 15 pp. BIS, New York. $0.65.

Étude Photoélasticimétrique d'une Entaille Calculable. J. Aubaud. *La Recherche Aéronautique*, Mar.-Apr., 1953, p. 35. In French. Photoelasticometric study of a notched bar calculated by

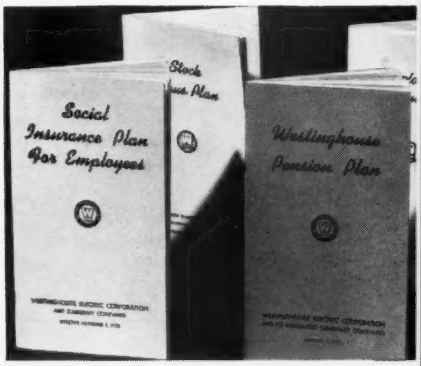


Look at these new opportunities in jet engineering at Westinghouse

1. Immediate openings in research, development and manufacturing at our Aviation Gas Turbine Division in Philadelphia or Kansas City, Mo. Salaries are good, varying with experience and ability. You'll enjoy working with us.

2. Challenging work offers the opportunity of joining with Westinghouse, a long-time leader in jet engineering.

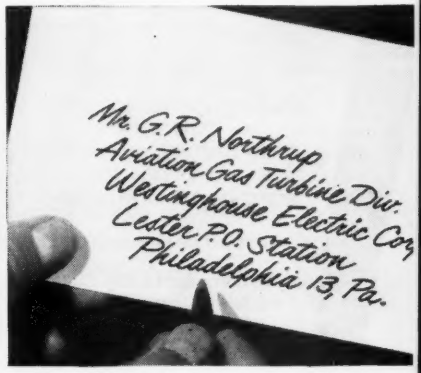
3. Incentive awards are given for inventions and ideas. Creative work is recognized and rewarded. We even pay your tuition for graduate study.



4. "Extras" include a modern pension plan; low-cost life, health, and accident insurance; stock purchase plan.

5. Security we consider important. Promotion is from within. We're in this new, expanding industry to stay.

6. Living conditions in Philadelphia and Kansas City suburbs are good with easy access to recreational activities. We will help you find housing.



7. Write today to this address; send full details. We'll arrange for a confidential interview for all qualified applicants.

J-54023

YOU CAN BE **SURE**... IF IT'S

Westinghouse

ENGINEERS
AND
SCIENTISTS

You are invited to write regarding long-range projects at Northrop Aircraft, Inc. Exceptional opportunities now exist to join the company's engineering and scientific staff. If qualified, you may select important developmental work, or equally vital production engineering.

Examples of positions open:

BOUNDARY LAYER RESEARCH SCIENTISTS
ELECTRONIC PROJECT ENGINEERS
ELECTRONIC INSTRUMENTATION ENGINEERS
RADAR ENGINEERS
FLIGHT-TEST ENGINEERS
STRESS ENGINEERS
AERO- AND THERMODYNAMICISTS
SERVO-MECHANISTS
POWER-PLANT INSTALLATION DESIGNERS
STRUCTURAL DESIGNERS
ELECTRO-MECHANICAL DESIGNERS
ELECTRICAL INSTALLATION DESIGNERS
ENGINEERING DRAWING CHECKERS

Qualified engineers and scientists who wish to locate permanently in Southern California are invited to write for further information regarding these interesting, long-range positions. Include an outline of your experience and training. Allowance for travel expenses.

Address correspondence to

Director of Engineering,
Northrop Aircraft, Inc.
1005 E. Broadway, Hawthorne, Calif.

Neuber; methods of calibration with experimental results.

Frequencies of Longitudinal Vibration for a Slender Rod of Variable Section. James L. Lubkin and Yudell L. Luke. *J. Appl. Mech.*, June, 1953, p. 173.

The Plastic Yielding of Notched Bars Due to Bending. A. P. Green. *Quart. J. Mech. & Appl. Math.*, June, 1953, p. 223. Estimation of applied loads necessary to cause plastic deformation.

The Shearing of a Rectangular Block Between Rough Plates. J. W. Craggs. *J. Appl. Mech.*, June, 1953, p. 270.

The Torsion of Spiral Rods. H. Ōkubo. *J. Appl. Mech.*, June, 1953, p. 273.

Beams & Columns

Analyzing Beam Vibration. George Sonnemann. *Mach. Des.*, June, 1953, p. 123. A simplified method for determining the natural frequency of uniform or nonuniform section beams.

Creep-Buckling Analysis of Rectangular-Section Columns. Charles Libove. *U.S., NACA TN 2956*, June, 1953. 24 pp.

The Effects of Shear Flexibility and Rotatory Inertia on the Bending Vibrations of Beams. I—Theoretical Study of the Vibrations of Uniform Beams. II—Experiments on the Vibrations of a Quasi-Uniform Beam. III—The Effects of Shear Stiffness on the Bending Vibrations of the Bristol Brabazon I Wing. R. W. Traill-Nash and A. R. Collar. *Quart. J. Mech. & Appl. Math.*, June, 1953, pp. 186; 188; 210; 219. 16 refs. Investigations at U. of Bristol, England.

Forced Lateral Vibration of Beams on Damped Flexible End Supports. D. F. Miller. *J. App. Mech.*, June, 1953, p. 167.

Natural Frequencies of Twisted Cantilever Beams. D. D. Rosard. *J. Appl. Mech.*, June, 1953, p. 241. An experimental and analytical investigation of the effect of twist for various width-to-thickness ratios.

Pure Bending of an Incomplete Torus. M. A. Sadowsky and E. Sternberg. *J. Appl. Mech.*, June, 1953, p. 215. 22 refs.

Reinforced Circular Holes in Bending With Shear. S. R. Heller, Jr. *J. Appl. Mech.*, June, 1953, p. 279.

Cylinders & Shells

The Flexural Vibrations of Thin Cylinders. R. N. Arnold and G. B. Warburton. *IME Proc. (A)*, No. 1, 1953, p. 62, Communications, p. 74.

An Invariant Membrane Stress Function for Shells. H. L. Langhaar. *J. Appl. Mech.*, June, 1953, p. 178.

A Note on the Finite Extension and Torsion of a Circular Cylinder of Compressible Elastic Isotropic Material. A. E. Green and E. W. Wilkes. *Quart. J. Mech. & Appl. Math.*, June, 1953, p. 240.

Response of an Elastic Cylindrical Shell to a Transverse, Step Shock Wave. R. D. Mindlin and H. H. Bleich. *J. Appl. Mech.*, June, 1953, p. 189.

Strain Energy Analysis of Swept Boxes with Ribs Normal to the Spars. D. Howe. *Coll. of Aeronautics, Cranfield, Rep. 63*, May, 1953. 49 pp.

Transient Thermal Stresses in Slabs and Circular Pressure Vessels. M. P. Heisler. *J. Appl. Mech.*, June, 1953, p. 261. 23 refs.

Elasticity & Plasticity

Linear Elastic Stability; A Critical Analysis of Methods. II. Hans Ziegler. *ZAMP*, May 15, 1953, p. 167. 37 refs. General analysis of buckling by compression and torsion and of critical angular velocities.

On Dynamical Problems of Plane Stress and Plane Strain. R. E. D. Bishop. *Quart. J. Mech. & Appl. Math.*, June, 1953, p. 250.

On the Plastic Strains in Slabs with Cutouts. P. G. Hodge, Jr. *J. Appl. Mech.*, June, 1953, p. 183.

Stresses Due to Tangential and Normal Loads on an Elastic Solid with Application to Some Contact Stress Problems. J. O. Smith and Chang Keng Liu. *J. Appl. Mech.*, June, 1953, p. 157. 15 refs.

Plates

Axisymmetric Flexural Temperature Stresses in Circular Plates. J. E. Goldberg. *J. Appl. Mech.*, June, 1953, p. 257.

The Buckling of Triangular Plates Under Combined Compression and Shear. J. Guest. *Australia, ARL S&M Note 203*, Mar., 1953. 14 pp.

Compressive Buckling of Plates Due to Forced Crippling of Stiffeners. I, II. P. P. Bijlaard and G. S. Johnston. *Bell Aircraft Rep. 02-941-025*, Sept. 25, 1953. 167 pp. 35 refs. [Also available as *IAS, SMF Fund Paper FF-8 (Preprints 408, 408A)*, Jan., 1953. Members, $1.30; Nonmembers, $2.00.] Analysis of buckling and the ultimate compressive stresses of stringer panels and multiweb beams with the skin attached to the flanges of the stiffeners by means of rivets or bolts; derivation of the equations for post buckling in the forced crippling mode.

Compressive Buckling of Stiffened Plates. I, II. B. H. Falconer and J. C. Chapman. *The Engr.*, June 5, 12, 1953, pp. 789; 822. Analysis of the critical and post-buckling behavior of long, simply supported, rectangular plates having any degree of longitudinal and transverse stiffening when subjected initially to uniform end-thrusts.

Critical Bending Stress for Flat Rectangular Plates Supported Along All Edges and Elastically Restrained Against Rotation Along the Unloaded Compression Edge. James H. Johnson, Jr., and Robert G. Noel. *J. Aero. Sci.*, Aug., 1953, p. 535.

Effect of Variation in Rivet Strength on the Average Stress at Maximum Load for Aluminum-Alloy, Flat, Z-Stiffened Compression Panels that Fail by Local Buckling. Norris F. Dow, William A. Hichman, and B. Walter Rosen. *U.S., NACA TN 2963*, June, 1953. 17 pp.

Flexural Vibration of the Square Plate with a Central Circular Hole. Toyoji Kumai. *Kyushu U., Japan, Rep. Res. Inst. Appl. Mech.*, Dec., 1952, p. 123.

Méthode des Différences Finies Appliquée aux Problèmes Bidimensionnels de Calcul des Contraintes d'une Plaque. F. Salles and C. Thorn. *France, Min.*

de l'Air BST 115, 1951. 85 pp. 15 refs. In French. Method of finite differences applied to the calculation of two-dimensional problems of stress and strain of plates.

Some New Types of Orthotropic Plates Laminated of Orthotropic Material. C. Bassel Smith. *J. Appl. Mech.*, June, 1953, p. 286.

Thermodynamics

The Condensation Line of Air and the Heats of Vaporization of Oxygen and Nitrogen. George T. Furukawa and Robert E. McCoskey. *U.S., NACA TN 2969*, June, 1953. 30 pp. 25 refs. Determination of the basic thermal properties of liquid air and its components to aid in the development of the theory of condensation in wind tunnels.

Combustion

Analytical (Power Series) Solutions to the Equations of Flame Propagation. J. O. Hirschfelder and Edwin S. Campbell. *U. Wis. NRL Dept. Chem. Rep. CM-784*, May 27, 1953. 118 pp. 29 refs.

Combustion. F. T. McClure and W. G. Berl. *Ind. & Eng. Chem.*, July, 1953, p. 1415. 42 refs. Flame propagation in terms of the interaction of processes of heat conduction, diffusion, and chemical reaction.

Material Transfer in Turbulent Gas Streams; A Coaxial Flame. V. J. Berry, D. M. Mason, and B. H. Sage. *Ind. & Eng. Chem.*, July, 1953, p. 1596. 34 refs. Combustion studies at CIT.

The Mechanism of Formation of OH, CH and HCO in Flame Spectra, using Deuterium as Tracer. H. P. Broida and A. G. Gaydon. *Proc. Royal Soc. (London), Ser. A*, June 9, 1953, p. 60. 15 refs.

Méthode de Mesure et d'Enregistrement Rapide des Témperatures des Flammes. (Rapid Method of Measurement and Recording of Flame Temperatures.) II. A. Moutet. *La Recherche Aéronautique*, July-Aug., 1952, p. 21. 30 refs. In French. Investigation of possibilities of recording, at high or low speeds, combustive actions in order to determine real temperatures of clear or nonclear flames.

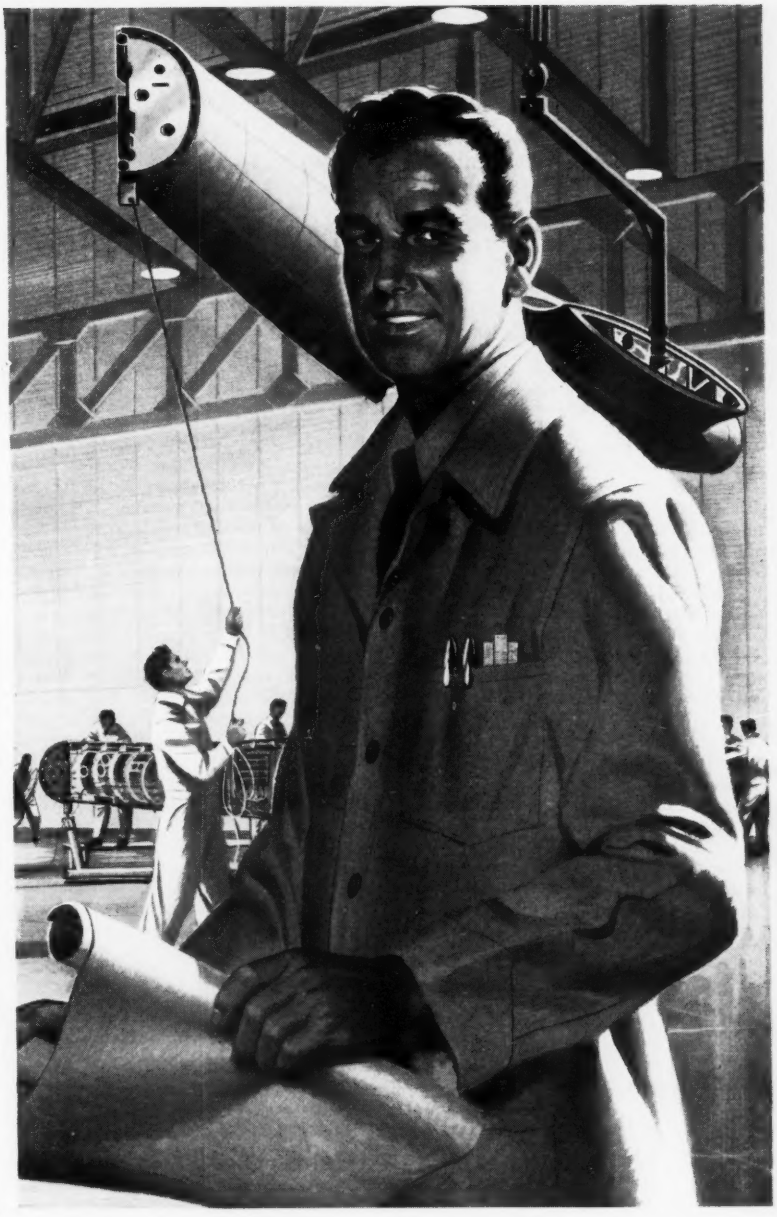
The Thermodynamics of Combustion Gases: Temperatures and Composition of the Combustion Products of Oxyacetylene Flames. Helen E. Edwards, Robert W. Smith, Jr., and Stuart R. Brinkley, Jr. *U.S., Bur. Mines Rep. Invest. 4958*. 7 pp.

Heat Transfer

Behavior of Materials Under Conditions of Thermal Stress. S. S. Manson. *U.S., NACA TN 2933*, June, 1953. 105 pp. 22 refs. Review of available information on stress and strain behavior of brittle and ductile materials subjected to certain thermodynamic conditions.

Forced-Convection Heat-Transfer Characteristics of Molten Sodium Hydroxide. Milton G. Grele and Louis Gedeon. *U.S., NACA RM E52L09*, Feb. 17, 1953. 27 pp.

Une Méthode de Mesure du Délai de Vaporisation (A Measuring Method for Time of Vaporization). J. Vidron. *La*



Northrop's Prime Equation

Northrop Aircraft production specialists initiate and install time-saving, cost-saving methods. The "half-shell" assembly technique, illustrated above, permits free installation of equipment in Scorpion F-89 interceptors now in production. Equations are used to solve problems. At Northrop Aircraft, the prime equation combines teams of administrators, outstanding scientists, and production specialists with modern industrial and research facilities. The combination efficiently converts imagination and knowledge into actual matériel of advanced design and incalculable value.

NORTHROP AIRCRAFT, INC.
HAWTHORNE, CALIFORNIA
Pioneer Builders of Night and All Weather Fighters
5A13

Recherche Aéronautique, July-Aug., 1952, p. 39. In French. Particular case of uniform high-speed flow, in terms of evaporation theories of isolated injected drops as used in ram-jets and heat-exchangers.

On the Unique Determination of Solutions of the Heat Equation. W. Fulks. *Pacific J. Math.*, June, 1953, p. 387.

The Thermal Conductivity of Metals in High Magnetic Fields at Low Temperatures. K. Mendelssohn and H. M. Rosenberg. *Proc. Royal Soc. (London), Ser. A*, June 25, 1953, p. 190. 24 refs.

The Thermal Conductivity of Solid Helium at High Densities. F. J. Webb and J. Wilks. *Philos. Mag.*, June, 1953, p. 664.

Water-Borne Aircraft

Hydrodynamic Impact of a System with a Single Elastic Mode. I—Theory and Generalized Solution with an Application to an Elastic Airframe. Wilbur L. Mayo. (*U.S., NACA TN 1398*, 1947.) *U.S., NACA Rep. 1074*, 1952. 17 pp. Supt. of Doc., Wash. $0.20.

Towing Tank Tests on a Large Six-Engine Flying Boat Seaplane, to Specification 10/46 Princess. I—General Porpoising Stability, Trim and Spray Clearance. A. G. Smith, G. L. Fletcher, T. B. Owen, and D. F. Wright. *Gt. Brit., ARC R&M 2641* (Jan., 1948), 1953. 29 pp. BIS, New York. $1.80.

Der Aufschlag von Rotationskörpern auf eine Wasseroberfläche. C. Schmieden. *ZAMM*, Apr., 1953, p. 147. In German. The impact of bodies of revolution on a free water surface.

Hydrodynamic Impact of a System with a Single Elastic Mode. II—Comparison of Experimental Force and Response with Theory. Robert W. Miller and Kenneth F. Merten. (*U.S., NACA TN 2343*, 1951.) *U.S., NACA Rep. 1075*, 1952. 7 pp. Supt. of Doc., Wash. $0.15.

Wind Tunnels & Research Facilities

Construction de Maquettes Dynamiquement Semblables Destinées à l'Étude du Flutter en Soufflerie. R. Melzer. *France, ONERA Pub. 59*, 1952. 52 pp. 14 refs. In French. Different methods for construction of dynamically similar models to study "flutter" in wind tunnels.

Contribution à l'Étude de l'Intensité des Bandes d'Absorption Infrarouge. Gilbert Amat. *France, Min. de l'Air PST 276*, 1953. 116 pp. 72 refs. Theoretical and experimental investigation of the problem of total absorption for spectrographic analyses and determination of the intensity of infrared bands; new research method for the measurement of intensities; application to the study of the properties of chloroform, pentachlorethane, trichlorethylene, and tetrachloroacetylene. (In French.)

Design and Calibration of the Institute of Aerophysics 16 In. × 16 In. Supersonic Wind Tunnel. W. B. Fallis, G. W. Johnston, J. D. Lee, N. B. Tucker, and J. H. Wade. *U. Toronto Inst. Aerophys. Rep. 15*, Mar., 1953. 91 pp. 13 refs.

Méthode d'Enregistrement Continu et Automatique de la Transparence Acoustique des Structures Légères. M. Kobrynski and A. Neyron. *La Recherche Aéronautique*, Sept.-Oct., 1952, p. 31. In French. Experimental method and instrumentation for the automatic and continual recording of variations of acoustic transparency of light structures; application to the analysis of the fuselage and other airframe components of the SNCASO Nene SO-30 Turbojet.

Quelques Mesures de Corrélation dans le Temps et l'Espace en Soufflerie. A. Favre, J. Gaviglio, and R. Dumas. *La Recherche Aéronautique*, Mar.-Apr., 1953, p. 21. 19 refs. In French. Spectral analyzers and measuring instruments for statistical correlation in longitudinal time and space of turbulent speeds in wind tunnels.

La Strioscopie Stéréoscopique. C. Veret. *La Recherche Aéronautique*, Sept.-Oct., 1952, p. 3. In French. Stereoscopic strioscopy methods and apparatus used in ONERA research laboratories; applications.

Sur la Mesure des Gradients en Analogies Rhéoelectriques; Appareil pour le Relevé Direct des Isovitesses. Jean Miroux. *La Recherche Aéronautique*, Sept.-Oct., 1952, p. 9. In French. On the measure of gradients in electrical analogies; description of apparatus for registering directly various isospeeds; applications and prospects for the future.

Techniques of Flow Visualization; A Discussion of the Fundamentals with Examples of Techniques Used in Research. E. Balint. *Aircraft Eng.*, June, 1953, p. 161. 28 refs.

Tunnel Wall Effect from Mass Flow Considerations. A. Thom. *Gt. Brit., ARC R&M 2442* (Nov. 11, 1947), 1952. 10 pp. BIS, New York. $0.75. Extension of the usual blockage formulas to high subsonic speeds.

Winds for Wings. John A. Killick. *Pegasus*, June, 1953, p. 1. Design of wind-tunnel, gas-dynamics, and testing facilities at the Arnold Engineering Development Center, Tenn.

IAS Twenty-Second Annual Meeting

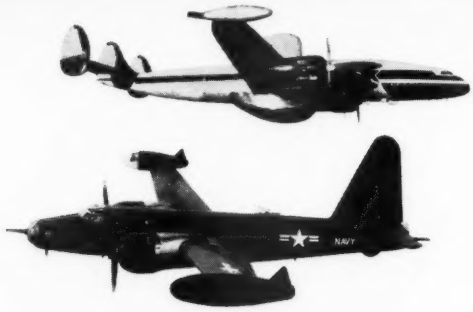
Authors wishing to have papers considered for presentation at this meeting should submit outlines or short abstracts to the Meetings Committee, 2 East 64th St., New York 21, N.Y., no later than September 15, 1953.

When you write to manufacturers whose advertising appears in the

Aeronautical Engineering Review,

it will be of interest to the companies and of benefit to the Institute if you mention that you saw it in the

Aeronautical Engineering Review



Three reasons

why Lockheed in California

offers

better careers for engineers

This capacity to develop and produce such a wide range of aircraft is important to career-conscious engineers. It means Lockheed offers you broader scope for your ability. It means there is more opportunity for promotion with so many development and production projects constantly in motion. It means your future is not chained to any particular type of aircraft—because Lockheed is known for leadership in virtually all types of aircraft.

Lockheed's versatility in development and production is also one of the reasons it has an unequaled record of production stability year after year.

1 *Diversified Production*

Huge luxury airliners, cargo transports, fighters, bombers, trainers and radar search planes are rolling off Lockheed assembly lines. Twelve models are in production.

2 *Diversified Development Projects*

The most diversified development program in Lockheed's history is under way—and it is still growing. The many types of aircraft now in development indicate Lockheed's production in the future will be as versatile as it is today—and has been in the past.

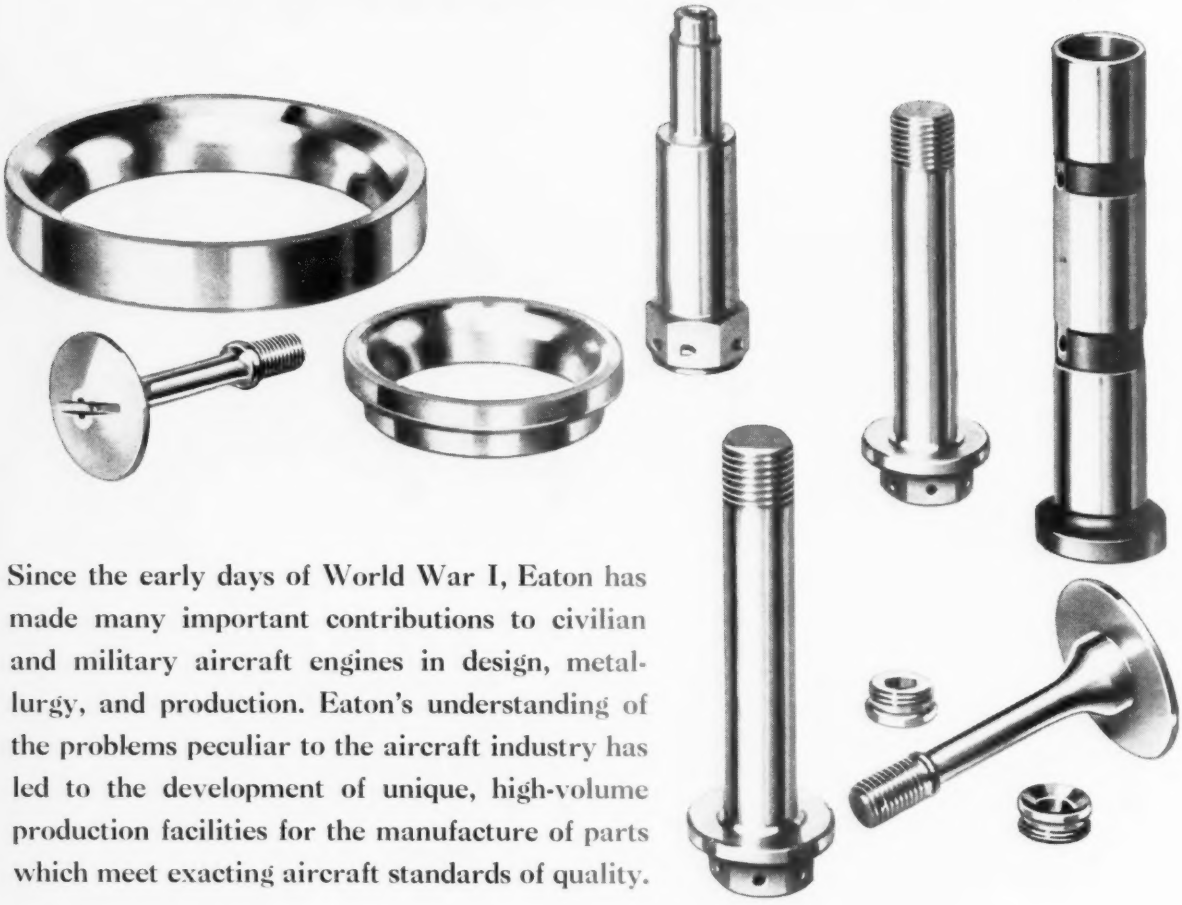
3 *Diversified Living*

You work better in Lockheed's atmosphere of vigorous, progressive thinking—and you live better in Southern California. You enjoy life to the full in a climate beyond compare, in an area abounding in recreational opportunities for you and your family.

Lockheed AIRCRAFT CORPORATION
Burbank, California

Aircraft Parts by Eaton

combine outstanding developments in design, metallurgy, and production engineering



Since the early days of World War I, Eaton has made many important contributions to civilian and military aircraft engines in design, metallurgy, and production. Eaton's understanding of the problems peculiar to the aircraft industry has led to the development of unique, high-volume production facilities for the manufacture of parts which meet exacting aircraft standards of quality.

EATON MANUFACTURING COMPANY

General Offices: CLEVELAND, OHIO

SAGINAW DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springlites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Aeronautical Reviews — BOOKS

Book Notes

ELECTRONICS

Index. Edited by Keith Henney. (M.I.T. Radiation Laboratory Series, Vol. 28.) New York, McGraw-Hill Book Company, Inc., 1953. 160 pp. $4.50.

This unified index is a complete subject guide to the M.I.T. Radiation Laboratory Series. This series offers in 27 monographs the special aspects of the program conducted under the Office of Scientific Research and Development. It not only covers the essential features of the work of the Radiation Laboratory itself, but also presents a full compilation and account of the status of technical developments in the entire field from laboratories throughout the world to the end of World War II. This index volume is concerned with subjects only; names of persons, companies, and laboratories are to be found in the individual volumes. The index volume also includes three short papers: Establishment of the Radiation Laboratory, Karl T. Compton; Organization of the Radiation Laboratory, Lee A. DuBridge; Preparation of the Radiation Laboratory Series, Louis N. Ridenour.

FILING

Filing Manual for Aircraft Correspondence. L. P. Bradley, Jr. Normandie, Mo., L. P. Bradley, Jr., 1953. 240 pp. $5.00.

The procedures and subject headings offered in this manual are intended for use in a company's master or central filing department, its engineering files, its project files, or in any department or office where even a small amount of technical correspondence is handled. Directed particularly to the nontechnically trained file clerk, secretary, or stenographer, the manual is put forward also as an engineer's filing system. The first portion of the book is given over to general remarks and suggestions pertaining to the method of filing, work flow, personnel, definitions of technical terms, and classified lists of file headings. The final part, of 197 pages, consists of an alphabetic list of subjects, for each of which a heading is given which corresponds to the type of file in use—i.e., whether it is large, medium-sized, or small. The procedures and system described were placed into effect and were operated successfully in the various departments and offices at the McDonnell Aircraft Corporation, where the author is Supervisor—Files and Library.

MATERIALS

Refractory Hard Metals. Paul Schwarzkopf and Richard Kieffer, in collaboration with Werner Leszynski and Fritz Benesovsky. New York, The Macmillan Company, 1953. 447 pp., illus., diagrs. $10.

The present volume is limited essentially to a coverage of structure, preparation, and properties of the pure carbides, borides, nitrides, and silicides—in other words, to a treatment of the substances that represent the basic constituents of the metal-bonded ("cemented") products now widely used as tool and wear- and heat-resistant materials. The production and applications of cemented hard metals, essentially cemented carbides, are to be treated in a subsequent book. The chapters dealing with high-temperature materials represent not only a critical evaluation of the usefulness of hard-metal compositions in applications such as turbine buckets or rocket nozzles, but also, to some extent, a general survey of the present status of development in the entire field of high-temperature materials. The work is based on a critical evaluation of the literature, supplemented by previously unpublished material originating from the experience of the authors and their collaborators. There are a 13-page subject index and an 8-page author index to the many references cited in the footnotes.

Proceedings at a Symposium on Aluminium Alloy Castings; Birmingham, November 6, and London, November 11, 1952. London, The Aluminium Development Association, April, 1953. 223 pp., illus., diagrs. 4*s*.

Contents: An Introduction to Aluminium Alloy Castings, D. C. G. Lees. The Importance of Standards for Aluminium Alloy Castings, F. Elliott and F. H. Smith. A Survey of Some Researches on Aluminium Founding, W. A. Baker. Developments in Finishing Aluminium Castings, A. P. Fenn. The Assembly of Aluminum Components by Welding, H. W. Keeble. Recent Developments in Aluminium Foundry Practice, E. Player. An Aluminium Automobile Cylinder Block Produced by Gravity Die-Casting, A. Eyden. Unusual Examples of Pattern and Die Construction, G. L. Turner, J. W. James, and A. Ratcliffe. Aluminium Alloy Castings Made With Inserts "Cast-In," J. Caven. Dental Stand, H. C. Cross. The Design of Aluminium Alloy Castings, L. Fletcher. The Future Outlook for Aluminum Castings, L. R. Carr. Discussions.

MECHANICS

Advances in Applied Mechanics, Vol. 3. Edited by Richard von Mises and Theodore von Kármán. New York, Academic Press, Inc., 1953. 323 pp., diagrs. $9.00.

Contents: Boundary Layer Problems in Applied Mechanics, G. F. Carrier. The One-Dimensional Isentropic Fluid Flow, Othar Zaldastani. Turbulent Diffusion: Mean Concentration Distribution in a Flow Field of Homogeneous Turbulence, F. N. Frenkiel. On Aerodynamics of Blasts, H. F. Ludloff. On the Presence of Shocks in Mixed Subsonic-Supersonic Flow Patterns, Gottfried Guderley. Vortex Systems in Wakes, L. Rosenhead. Some Recent Results in the Theory of an Ideal Plastic Body, Hilda Geiringer. Non-Autonomous Systems, Albert I. Bellin. Author Index.

For Information on IAS Library Service Facilities, see page 87

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

PHYSICS

Introduction to Solid State Physics. Charles Kittel. New York, John Wiley & Sons, Inc., 1953. 396 pp., illus. $7.00.

This volume is intended as an introductory textbook in solid-state physics for senior and beginning graduate students in physics, chemistry, and engineering. In the selection of material, the author, Professor of Physics, University of California, has favored those areas that may be discussed in terms of simple, concrete, and well-developed models. Problem sets are included at the end of every chapter. The opening chapters are concerned with the classification of solids and crystal structures, lattice energy of ionic crystals, elastic constants of crystals, and lattice vibrations. Chapters 5 to 11 treat of thermal properties of solids, dielectric properties, ferroelectric crystals, diamagnetism, paramagnetism, ferromagnetism and antiferromagnetism, and superconductivity. The remaining chapters are discussions of the free electron and band theories of metals; semiconductors; and imperfections in solids. Advanced topics, particularly those requiring a formal background of quantum mechanics, are developed in appendixes.

POWER PLANTS

Aircraft Engines of the World, 1953. Paul H. Wilkinson. New York, Paul H. Wilkinson, 1953. 320 pp., illus. $12.

The eleventh edition of this reference work on aircraft engines presents the latest information on jet and piston engines from all over the world. Data are given in standardized page form with numerous illustrations, and the contents are up to date as of May 1, 1953. The introduction reviews current activities in the engine and equipment fields. A new feature in the Jet Engines and Gas Turbines section, which now numbers 150 pages, is a standardized method of describing the control systems of the engines. Twelve new main jet power plants have been added to this section. The Tabulations of Aircraft and Their Engines have been expanded to include tabulations of air liners, cargo airplanes, and helicopters. The Reciprocating Engines section, greatly revised, contains complete descriptions of 61 engines. JP-5 jet fuel and synthetic lubricating oils for jet engines have been added to the fuels and lubricants section.

(*Concluded on page 137*)

something to think about

Peace in our time depends upon plenty of *this* sort of thing:

"We were given a map," said the man from Martin, "and a target to be destroyed. Problem was to produce the hardware—the optimum weapons system to destroy that target."

That's as far as he would go. Except to say this:

It looks like nothing ever flown by man. Pilotless. Can be launched from a pad of scorched earth. A team of Martin scientists and engineers in five branches of aeronautical engineering produced this thing in a matter of months from problem to proving ground.

Today at Martin an entirely new concept, known as Martin Systems Engineering, is resulting in the production of new aircraft, guided missiles and electronics weapons designed not as yesterday's flying vehicles but as the coordinated and controlled spaceborne systems of tomorrow.

The principle of Martin Systems Engineering now makes possible developments in airpower that may change the shape of things to come—our way!

You'll hear more about Martin.

Martin AIRCRAFT

THE GLENN L. MARTIN COMPANY
BALTIMORE • MARYLAND

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Aeronautical Engineer—Preferably with M.S. degree, to teach aeronautical engineering course, provide aeronautical consulting services, develop through theory and experiment new test methods in the field of flight testing, is needed by the Test Pilot Training Division of the Naval Air Test Center at Patuxent River, Md. Civil Service rating GS-9 to GS-11. Send résumé or Form 57 to Dr. W. J. Hesse.

Engineer—The Naval Air Missile Test Center, Point Mugu, Calif., has an opening for an aeronautical or general engineer, GS-12, $7,040 per annum. Description: Engineer in charge of Stress Group to perform structural analysis of aircraft modification, aircraft installations, missile components, and mechanical mechanisms and installations. Applicants should submit Standard Form 57, Application for Federal Employment (available at any Post Office), to the Commanding Officer (43), U.S. Naval Air Station, U.S. Naval Air Missile Test Center, Point Mugu, Port Hueneme, Calif.

Engineers—Opportunities for employment exist in the Bureau of Aeronautics, Department of the Navy, Washington, D.C. **Aeronautical Power-Plant Research Engineer**—GS-12, $7,040 per annum. Development of general designs and studies of reciprocating, turbojet, turboprop, ram- and pulse-jet, and rocket engines to be used in subsonic and supersonic land- and carrier-based aircraft and guided missiles. Requirements: 3½ years of professional engineering experience in addition to degree. **Mechanical Engineer**—GS-12, $7,040 per annum. Responsible for conducting investigations, studies, and projects in gas dynamics. Serves as expert, specialist, and consultant on gas dynamics for the purpose of guiding the development of new naval aircraft power plants. Plans, initiates, and supervises research, design, development, and tests of landing aids. Participates in review and evaluation of design studies made by contractors. Prepares test, installation, performance, and detailed specifications for landing aids and systems. Requirements: 3½ years of professional engineering experience in addition to degree. **Electronic Engineer (Radio)**—GS-12, $7,040 per annum. Interprets present and future military requirements for antisubmarine air-borne radar systems. Analyzes existing fleet equipment of this type to determine what improvements can be made to improve its efficiency for meeting operational requirements. Coordinates the research and development programs with other interested services, bureaus, and agencies. Requirements: 3½ years of professional engineering experience in addition to degree. **Aircraft Stability Control Engineer**—GS-12, $7,040 per annum. Plans, initiates, and coordinates guided-missile flight research and flight research and flight evaluation programs. Directs and carries out evaluations of the stability and control characteristics of proposed new guided missiles. Prepares specifications pertaining to aerodynamics analyses, especially stability and control of guided missiles. Requirements: 3½ years of professional engineering experience in addition to degree. **Aeronautical Development Engineer—(Hydrodynamics),** GS-11, $5,940 per annum. Under general supervision performs highly specialized aeronautical engineering work in the field of hydrodynamics in connection with design of naval aircraft; assists in model and full-scale, research and development projects in hydrodynamics for improvement of seaplane operation. Requirements: 2½ years of professional engineering experience in addition to degree. **Natural Gas Engineer**—GS-11, $5,940 per annum. Devising or examining and approving containers for the storage and transportation of helium. Experience in pressurization and compression systems; knowledge of methods and devices for controlling gases under pressure. Requirements: 2½ years of professional engineering experience in addition to degree. **Mechanical Engineer**—GS-9, $5,060 per annum. Prepares studies and layouts of test facilities for experimental and operational catapults and associated equipment for development of new systems and improvement of existing equipment; prepares preliminary analytical studies of catapulting systems and associated components for launching piloted aircraft to determine theoretical performance characteristics, strength requirements, and optimum configuration. Requirements: 1¼ years of professional engineering experience in addition to degree. **Mechanical Engineer**—GS-9, $5,060 per annum. Prepares preliminary studies to determine the theoretical performance characteristics, strength requirements and configuration of experimental catapults and associated components. Evaluates design proposals submitted by contractors and Government activities in connection with catapulting equipment to determine conformance with accepted engineering practice. Requirements: 1¼ years of professional engineering experience in addition to degree. **Aircraft Structural Development Engineer**—GS-9, $5,060 per annum. Critical review and analysis of contractor stress calculations consisting of detailed analytical determination of stress tolerances for specific load, carrying structural members. Specification of usable materials for contractor design. Requirements: 1¼ years of professional engineering experience in addition to degree. Applications may be submitted on Standard Form 57, Application for Federal Employment, to the Department of the Navy, Bureau of Aeronautics, Personnel Division, Attention: PE-202, Washington 25, D.C. The Standard Form 57 is available at U.S. Post Offices or may be obtained by writing to the Personnel Division, Bureau of Aeronautics. Visitors to the Washington area may call at Room 3909 of the Main Navy Building, 19th and Constitution Ave., N.W., Washington, D.C.

Engineers—Unusual opportunities with one of the foremost creative engineering organizations in the United States. Located in central New Jersey. Now expanding in fields of Ordnance, Electromechanical and Electronic Devices, Aircraft and Missile Launchers and Catapults. Compression Distillation, Servomechanisms, etc. Qualifications: B.S. in Engineering, minimum of 3 years in any of the aforementioned fields. Salary commensurate with experience. Address replies to: Personnel Director, Power Generators Limited, 25 N. Montgomery Street, Trenton, N.J.

Engineers—Combine graduate study and employment in research. Educational benefits available while working full time or part time in analytical or experimental thermodynamics, fluid flow, and heat transfer. Project work in analysis of aircraft equipment cooling systems, thermal design, and evaluation of aircraft electronic equipment and rotating electrical machinery. Forward request for additional information with résumé of education and experience (indicating desired field of graduate study and degree) to: W. Robinson, 290 Robinson Laboratory, The Ohio State University, Columbus 10, Ohio.

Engineers, Technologists, Physicists, Physiologists, Metallurgists—The Navy Air Material Center located in the U.S. Naval Base at the extreme south end of Broad Street in Philadelphia, Pa., has vacancies in the above positions for qualified eligibles. These vacancies are at grade GS-5 to GS-12 level with salary ranging from $3,410 to $7,040 per annum. The Naval Air Material Center (the Air Center is divided into three major branches: the Naval Aircraft Factory, the Naval Air Experimental Station, and the Naval Auxiliary Air Station) is engaged in research (applied), development, manufacture, modification, test evaluation, and overhaul of aircraft, aircraft components, and aeronautical materials, including launching and arresting devices. This activity has the job of finding the answers to a never-ending series of problems involving the whole field of aeronautical sciences. Interested persons should file an Application for Federal Employment, Standard Form 57, with the Industrial Relations Department, Naval Air Material Center, Naval Base, Philadelphia 12, Pa. Applications may be obtained from the Industrial Relations Department, Naval Air Material Center, or at any first- or second-class Post Office or from any Civil Service Regional Office.

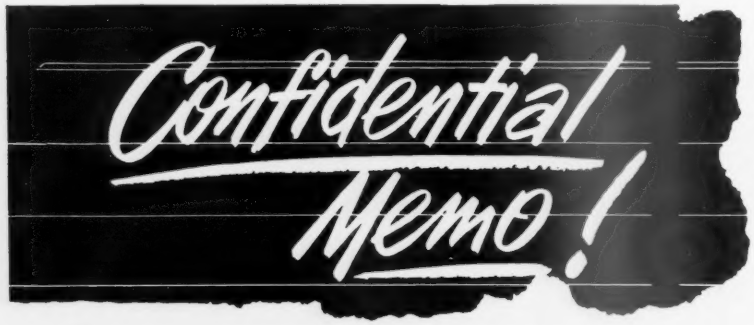
502. Dynamics Engineer—Expanding New England firm of research engineers has several offerings for aeronautical or mechanical engineers with experience in dynamics. Projects include dynamic analyses of complicated structures subject to transient inputs, vibration analyses, aeroelasticity studies, laboratory vibration testing, and flight testing. Excellent opportunity for advancement with this young organization.

500. Associate or Assistant Professor of Aeronautical Engineering—Opening available for immediate appointment by state university in eastern United States. Applicant should be qualified to teach undergraduate and graduate courses in aerodynamics and related work, including compressible flow theory. Advanced degree required. Opportunity for combined teaching and research program. Enclose résumé of education and experience in initial reply.

499. Engineers—The following positions are available at a large East Coast engine manufacturer. **Process Engineer**—Responsible for establishment of methods by which experimental

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

parts are to be manufactured. **Operation Sheet Writer, Senior**—To prepare operation sheets for any machining or assembly work through all steps to completion and to make estimates of tooling requirements. **Design Engineer, Senior**—To execute a variety of complex mechanical layouts of various components of reciprocating and gas-turbine engines, with related heat transfer and also stress and thermal calculations. **Analyst, Senior**—Responsible for actual execution of any advanced research or analysis projects in particular technical or scientific field (chemistry, metallography, stress analysis, etc.). **Operation Sheet Writer**—Prepare operation sheets and machine routings for machining of assembly work where difficult or unusual operations are not required. **Layout Draftsman, Senior**—Responsible for execution of complex layout drafting assignments involving basic design for assembly, strength and operation. **Tool Designer, Senior**—To design and draft a wide variety of tooling including jigs, fixtures, dies, and gages for use in machining and assembling parts or assemblies. **Design Engineer**—Responsible for execution of design projects covering engine assemblies or complex parts. **Test Engineer, Senior**—To execute advanced technical assignments relative to the planning and execution of experimental and development test programs. **Tool Designer**—To design and draft tooling such as jigs, fixtures, dies, and gages where there are no problems of unusual or difficult designs. **Test Engineer**—To execute fairly complicated technical assignments relative to the planning and execution of experimental or development test programs. **Test Engineer, Junior**—To execute fairly simple technical assignments relative to the planning and execution of various development test programs. **Design Analytical Engineer, Junior**—To perform less complicated theoretical analysis of engineering problems relative to the design of products. **Tool Designer, Junior**—To design and draft simple tooling working from rough sketches or instructions supplied by Chief, Tool Design Unit.



To: Experienced Engineers and Scientists

From: *South Wind* DIVISION
STEWART-WARNER CORPORATION

Re: A challenging, rewarding job!

This "memo" appears in Time Magazine and a number of other publications as well as in this magazine. This may seem to be a surprising amount of trouble and money to spend on a "want ad," but it reflects the emphasis we place on finding just the right men to fit into our developmental engineering departments.

This policy has resulted in our having the finest engineering staff in the fields of combustion and heat transfer. If you are the type of man we want, you will find working with these men an inspiration and a pleasure.

Here at South Wind, heating has been raised to a science. Our products have opened up a new horizon in domestic, automotive and aircraft heating—and the next few years will extend that horizon even further.

The men we want will have ME, EE or AE degrees and a minimum of three successful years of engineering experience. We offer outstanding inducements to the right men.

You will, if qualified for the jobs now open, be paid well, commensurate with your experience. You will be eligible for a pension plan, health insurance—all of the advantages that you'd expect working for a big, strong company that's the leader in its field.

If you're interested, and think we would be interested in you, write, telling of your experience, or use the coupon below. We'll keep it completely confidential, even return your letter if you wish, and you'll hear from us within two weeks.

Manager of Employment, Stewart-Warner Corporation, Dept. A-93
South Wind Division, 1514 Drover Street, Indianapolis 7, Indiana

I am interested in exploring the opportunities at South Wind.

Name .....

Address .....

City ..... State .....

SW STEWART-WARNER CORPORATION
South Wind DIVISION
1514 DROVER STREET, INDIANAPOLIS 7, INDIANA

498. Operations Research Man—With technical and economic background for interesting and varied and independent work on defense studies. Advanced degrees desirable. At least 3 years' industrial or operational experience required. Location, Washington, D.C., area.

495. Design Engineer—Instrument Division of a Midwestern manufacturer requires the services of a competent Design Engineer, one qualified to assist and design in diaphragm-type instruments such as Bank and Turn, Rate of Climb, Cabin Pressure Gages, Airspeed Indicators, and other basic flight instruments. A splendid opportunity is offered to the individual who has the necessary background and qualifications. Experience along similar lines is essential.

491. Hydraulic Design Engineers—Three to 5 years' experience. Aircraft background desirable. Firm is located within 100 miles of New York City.

Available

508. Aeronautical Engineer—Ph.D. in Applied Mechanics. Age 30. Six years' research experience in the field of hydro- and aerodynamics, elasticity, and structures. Desires a research and development position in the industry or research and/or teaching position in college. Salary open. Résumé furnished on request.

507. Professor of Aeronautics—B.S., M.S., and B.S.M.E. Registered Mechanical Engineer, State of California. Two years in guided missiles, 1 year responsible position as Branch Chief. Three years in industrial aircraft structures and mechanical equipment. One year as Professor of Aeronautics in structures. Four years as Associate Professor of Mechanical Engineering. Desires permanent position in university or supervisory and/or research position in guided missiles. Detailed résumé sent on request.

506. Aeronautical and Mechanical Engineer—M.S. in M.E.; Professional Engineer. Experience of 17½ years in turbojet, ram-jet, and rocket-propulsion systems and electronic instruments and controls design and development; helicopter and propeller design; and automatic pilot developments and automatic heating and machine tool design and development. Thirteen years acting in a supervisory and administrative capacity. Over 3 years as project officer in Air Research and Development Command, Engineering Division. Has security clearance rating. Desires to utilize this experience as manufacturer's field or sales representative in New York and New England area.

505. Aeronautical Engineer—Ph.D. Age 29; 1 years' teaching and 2 years' industrial experience. Desires teaching position in college or university located in the East. Research opportunities preferred. Field of interest: aerodynamics and elasticity.

504. Advertising and Public Relations Manager—B.S. in Engineering/Business Administration, MBA in Marketing. Age 33, 10 years' progressive experience in all phases of industrial promotion: program planning, budgeting and administration, agency and media liaison, space and promotional copy planning, writing and editing, pamphlets and brochures, and technical publicity. Press, industry, and Government relations. Licensed pilot, mechanic, and radio operator with background in aviation equipment, radio and electronics, and air transport. Desires position offering greater responsibilities and opportunity for advancement.

503. Engineer—M.E., M.S. Ten years' experience in electromechanical and servodynamics fields. Presently head of Development and Research Section for manufacturer of servomotors, gyros, and avionic systems. Desires administrative position in research and development.

NEW! A one-man Stretch-Wrap Former with instant work-length adjustment!

Designed to produce parts in an unusually wide range of work lengths, this new Hufford model 102 offers many work-saving features

ONE-MAN OPERATION—All loading and forming functions are easily controlled by a single operator.

INSTANT WORK-LENGTH ADJUSTMENT—Design has been reduced to its simplest form. Note work-length capacity is varied merely by extending or retracting cylinder rods to desired spacing between jaws.

WIDE RANGE OF LENGTHS—Parts as short as 12" or as long as 72" may be accommodated.

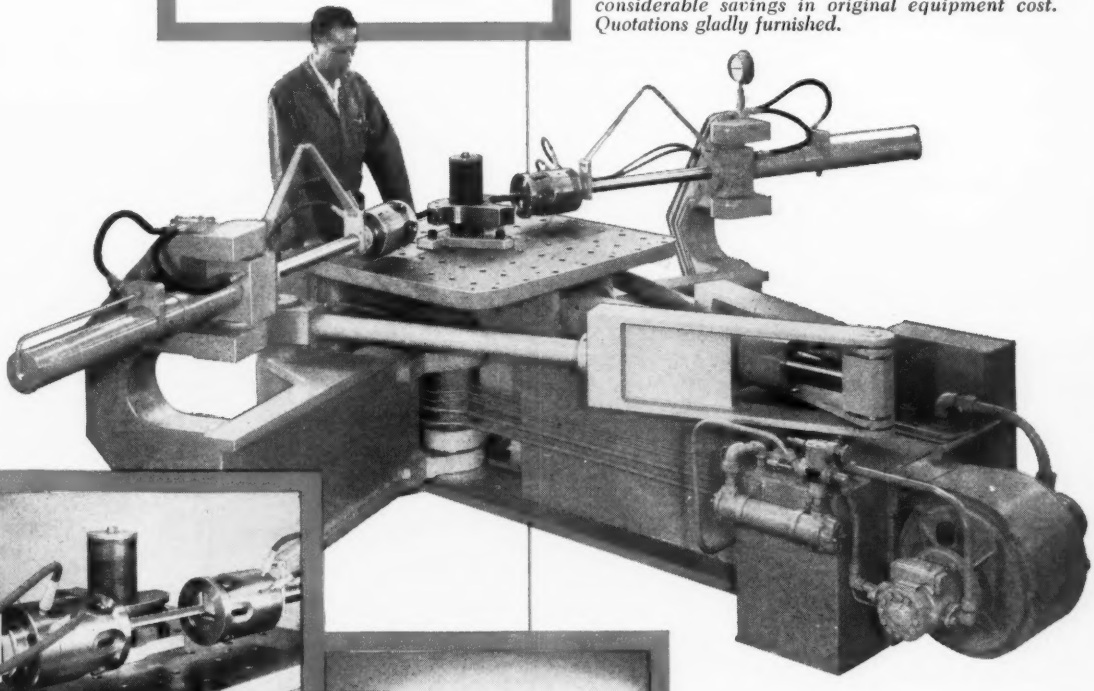
DOUBLING THE WORK-LENGTH CAPACITY is offered as a possibility by operating two machines side by side, disconnecting inside arms of each. Tension cylinder capacity remains the same.

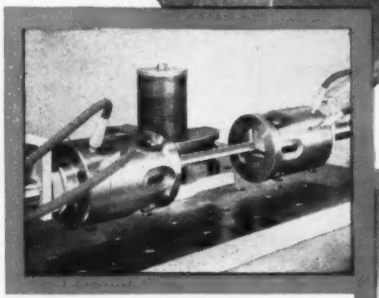
SIMULTANEOUS ARM MOVEMENT—Arms may be automatically stopped at any portion of their travel by electric controls.

MANUAL TENSION CONTROL—Tension pressure is applied by manually operated levers.

The new model 102 is Hufford's latest development towards modernization of existing equipment. It effectively relieves larger machines of the smaller jobs at considerable savings in original equipment cost. Quotations gladly furnished.

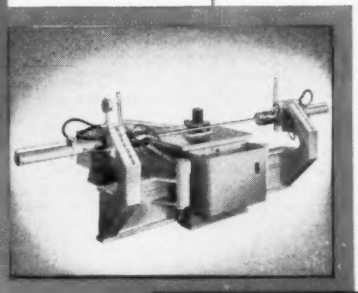
HUFFORD
MODEL 102
CAPACITY 5 TONS





The model 102 easily and quickly forms parts over an unusual range of lengths. Since both arms pivot on the same pin small radii and short parts are easily and economically produced.

With jaws fully retracted, finished parts up to 72" long may be formed.



BRIEF SPECIFICATIONS — MODEL 102

Tension Capacity	10,308 lbs.
Max. Die Height	10"
Min. Die Length for 180° Bend at Any Tonnage	7"
Max. Die Length for 180° Bend at Full Tonnage	45"
Tension cylinder stroke, each	30"
Maximum part length (tension cylinders fully retracted)	72"
Minimum part length	12"

HUFFORD
Machine Works Inc.
EL SEGUNDO, CALIFORNIA

Manufacturers of
PRECISION HYDRAULIC STRAIGHTENING PRESSES
HYDRAULIC METAL FORMING BULLDOZERS · HYDRAULIC STRETCH-LEVELING TABLES
HYDRAULIC STRETCH-WRAP FORMING MACHINES
PORTABLE HYDRAULIC ELEVATORS · HYDRAULIC COMPACTION PRESSES
CUSTOM-MADE HYDRAULIC MACHINE TOOLS AND ACCESSORIES

This titanium bolt produced by Harper meets the demands of today's aircraft for lighter, stronger fastenings.

The Harper Aero Division is producing fastenings of all the new high temperature alloys, such as Discaloy Refractaloy, A-286 and special grades of stainless steel.

Harper metallurgists will work with you on the production of fastenings to meet any design, temperature, abrasion or corrosion conditions.

THE H. M. HARPER COMPANY
AERO DIVISION
8282 Lehigh Avenue, Morton Grove, Ill.

HARPER
AERO DIVISION

Specialists in high temperature fastenings of—
Refractaloy • A-286
Inconel • Discaloy
Hastelloy Alloys
19-9-DL
Greek Ascalloy
Titanium
Stainless Steel

Over 85% of the torque wrenches used in industry are

STURTEVANT TORQUE WRENCHES

Read by Sight, Sound or Feel

- Permanently Accurate
- Practically Indestructible
- Faster—Easier to use
- Automatic Release
- All Capacities

in inch ounces
...inch pounds
...foot pounds
(All sizes from 0-6000 ft. lbs.)

Every manufacturer, design and production man should have this valuable data. Sent upon request.

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

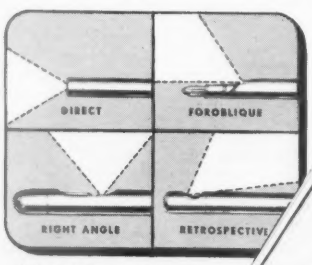
Imperial
THE Finest
TRACING CLOTH

Imperial is known in drafting rooms all over the world as the traditional quality tracing cloth.

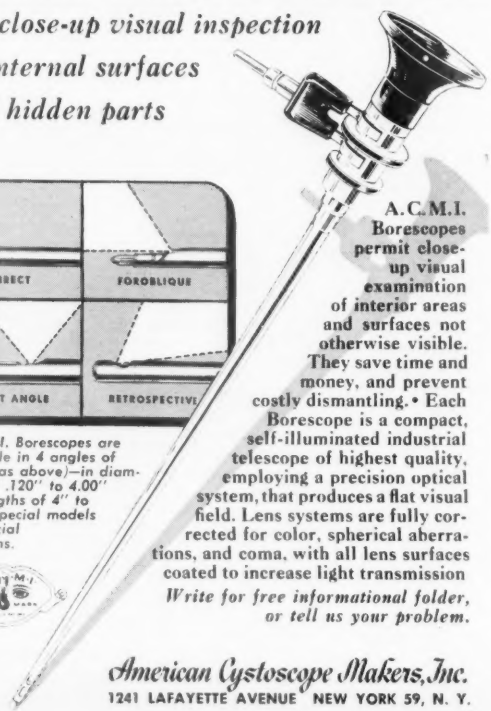
With the background of decades of experience, its makers have pioneered in modern improvements to maintain Imperial as the finest tracing cloth made.

A.C.M.I. BORESCOPES

for close-up visual inspection of internal surfaces and hidden parts



A.C.M.I. Borescopes are available in 4 angles of vision (as above)—in diameters of .120" to 4.00"—in lengths of 4" to 720". Special models for special problems.



A.C.M.I. Borescopes permit close-up visual examination of interior areas and surfaces not otherwise visible. They save time and money, and prevent costly dismantling. • Each Borescope is a compact, self-illuminated industrial telescope of highest quality, employing a precision optical system, that produces a flat visual field. Lens systems are fully corrected for color, spherical aberrations, and coma, with all lens surfaces coated to increase light transmission

Write for free informational folder, or tell us your problem.

American Cystoscope Makers, Inc.
1241 LAFAYETTE AVENUE NEW YORK 59, N. Y.

501. Young Electronics Management Executive—B.S., M.S. Offers knowledge gained as Vice-President with experience in Government sales, contract administration, purchasing, production, and engineering in the fields of electronics, rocket-motor research, and guided missiles. Reorganization, planning, and financing experience; a searching and creative mind to generate and recognize ideas. Locate anywhere. Minimum salary $15,000 plus.

497. Sales Engineer—M.S.Aero.E. Age 28; 5 years' experience in aeronautical engineering. Sales engineering position desired by aeronautical engineer. Present position Project Leader. Résumé furnished on request.

496. Mechanical Engineer—Age 32; 8 years' experience in aircraft testing and research on mechanical equipment and structures, including nearly 4 years supervising laboratory and test groups; responsibilities included the planning, scheduling, and supervision of civilian and military test programs. Desires responsible position in aircraft mechanical equipment design or development fields. Complete résumé upon request. Please indicate the nature and salary range of available positions.

494. Aeronautical Engineer—B.S.Ae.E. Desires responsible position in any foreign country for U.S. firm. Varied experience in research, test, production, and management and contract phases of aircraft, missile, reciprocating engines, and rocket power plants. Present position as an Administrative Engineer for aircraft corporation. Married. Age 29. Excellent personal and professional references.

492. Aeronautical Engineer and Technical Writer—M.S. in General Engineering. Over 15 years' diversified general and aeronautical stress and writing experience. Desires teaching position. Prefers New England or California location.

* * *

COMING IN DECEMBER ISSUE

AERONAUTICAL ENGINEERING REVIEW

"ENGINEERING TRENDS OF 50 YEARS"

A Special Issue Commemorating the 50th Anniversary of Powered Flight

Advertising Forms Close November 1st

SPACE RESERVATION ORDERS ACCEPTED NOW!

* * *

Book Notes

(*Concluded from page 131*)

SPACE TRAVEL

Man in Space. Heinz Haber. Indianapolis, The Bobbs-Merrill Company, Inc., 1953. 291 pp., illus. $3.75.

Man in Space is a study of the physical and psychological hazards that man must face in travel beyond the stratosphere. Dr. Haber, who is a member of the Department of Engineering at the University of California, explains the serious obstacles that may yet prohibit man's travel through space, but he also relates what evidence there is to support the hope of man's survival there. In terms understandable to the layman, he shows how experiments in the laboratory and experiences in modern aircraft may be used for a critical appraisal of the difficulties that await man in space—the stresses placed on the crew during the powered ascent; the state of weightlessness; the supply of breathing air and the control of temperature; and the dangers from meteorites, solar radiation, and cosmic rays. In the final chapter, the author shows how the shortcomings of man's earth-conditioned body and mind will eventually determine the limits of the space frontier.

STRUCTURES

Structural Principles and Data. Co-Editors: D. M. A. Lettett and M. Langley. Contributors: Part 1, W. Tye; Part 2, J. H. Argyris and P. C. Dunne. Published under the Authority of the Royal Aeronautical Society. 4th Ed. (Handbook of Aeronautics, No. 1.) New York, Pitman Publishing Corporation, 1952. 322 pp., diagrs. $8.50.

Part 1, Structural Airworthiness, has as its principal aim the treatment of the following problems: (a) the selection of maneuvering and other conditions appropriate to the intended use of the airplane, and the specification of these in terms of design cases; and (b) the estimation of the loading systems acting on the airplane structure arising from these design cases. Specifically, the loads discussed are: symmetric maneuvering loads, gust loads, tail-plane and elevator loads, aileron loads, landing-gear loads, engine mounting loads, and crash loads. A chapter is also devoted to problems associated with factors of safety. Part 2, Structural Analysis, is concerned with the estimation of the stresses, and hence the overall strength of the airplane structure under the applied loading system. This second part comprises about two-thirds of the book. Those parts of the theory are presented which are of particular interest in the design and analysis of stressed-skin structures. This part is divided into ten sections—namely, Introductory, Stress-Strain Relations and Properties of Aluminium Alloy Materials, Beams and Struts, Buckling of Plates and Panels, Flat and Curved Shear Panels in Incomplete Diagonal Tension, Wing Stressing, Diffusion in Flat Panels, Rings and Curved Beams, Fuselages with Flexible Rings, and References and Bibliography, which give more than 300 references to periodical and report literature. Concluding the volume is a subject index to both parts.

Studies in Elastic Structures. A. J. S. Pippard. London, Edward Arnold & Co.; New York, Longmans, Green and Co., Inc., 1952. 361 pp., diagrs. $11.50.

In this book the author has collected a number of studies of elastic structures which he and his colleagues made over a considerable period. The structures differ widely in type, and much of the work was started to provide answers to problems that had arisen in connection with actual designs. Considerable use is made of the principle of superposition to obtain results in a form suitable for reasonably quick computation, and in several problems the device of replacing a number of discrete members by a continuous medium having peculiar elastic properties has been adopted.

Contents: (1) The Stresses in Circular Rings; (2) The Stresses in Wheels and Braced Wings; (3) Stresses in Rotating Wheels; (4) Stresses in Interconnected Bridge Girders; (5) Multiple Lattice Frames; (6) Problems of Cable Bracing; (7) Stresses in a Restrained Pipe Line; (8) Analysis of Open-Panel Structures; (9) Bow Girders and Transversely Loaded Frames; (10) The Elastic Arch Rib; (11) The Masonry Arch; (12) Experimental Study of Stresses in a Braced Tube; Index.

History of Strength of Materials; With a Brief Account of the History of the Theory of Elasticity and Theory of Structures. Stephen P. Timoshenko. New York, McGraw-Hill Book Company, Inc., 1953. 452 pp., illus., diagrs. $10.

This book was written on the basis of lectures on the history of strength of materials given by the author during the last 25 years to students in engineering mechanics who already had knowledge of strength of materials and theory of structures. Included in the present history are brief biographies of the most prominent workers in this subject. Also provided are discussions of the relation of the progress of strength of materials to the state of engineering education and to the industrial development in various countries. Only those portions of the history of the theory of elasticity which are closely related to the development of strength of materials have been selected, and all material has been omitted which is related to the purely theoretical and mathematical progress of that science. In the same way, in dealing with the development of the theory of structures, the portions having only technical interest were not included in this book. Dr. Timoshenko has divided his work as follows: (1) The Strength of Materials in the Seventeenth Century; (2) Elastic Curves; (3) Strength of Materials in the Eighteenth Century; (4) Strength of Materials Between 1800 and 1833; (5) The Beginning of the Mathematical Theory of Elasticity; (6) Strength of Materials Between 1833 and 1867; (7) Strength of Materials in the Evolution of Railway Engineering; (8) The Mathematical Theory of Elasticity Between 1833 and 1867; (9) Strength of Materials in the Period 1867–1900; (10) Theory of Structures in the Period 1867–1900; (11) Theory of Elasticity Between 1867 and 1900; (12) Progress in Strength of Materials During the Twentieth Century; (13) Theory of Elasticity During the Period 1900–1950; (14) Theory of Structures During the Period 1900–1950; Name Index; Subject Index.

Statically Indeterminate Structures. Chu-Kia Wang. New York, McGraw-Hill Book Company, Inc., 1953. 424 pp., diagrs. $7.50.

The text covers methods of finding deflections of statically indeterminate beams, rigid frames, and trusses and the analysis of statically indeterminate structures by the method of consistent deformation, by the three-moment equation, by the slope deflection and moment distribution methods, and by the method of column analogy. The analysis of fixed arches, secondary stresses in trusses with rigid joints, and composite structures are also treated. Classroom helps consist of illustrative problems completely worked out in detail, and exercises. The author is Associate Professor of Civil Engineering, University of Colorado.

STRESS ANALYSTS

with actual aircraft stress experience

Also AIRCRAFT ENGINEERS AND DESIGNERS

Here's an opportunity to work in one of the most interesting and fastest-growing segments of the aviation field

HELICOPTERS

Sikorsky Aircraft—foremost designer, developer and manufacturer of helicopters—has recently expanded its plant (1) to increase production of the latest type combat-proved helicopters and (2) to expand its research and development program.
Here's your chance to work with the top men in your profession—men who made the first practical helicopter.

You'll Find at Sikorsky Aircraft

- a company with large and important orders
- an engineering staff of exceptionally high calibre
- unduplicated research and testing facilities
- a respect for and interest in new ideas

You'll Enjoy These Advantages

- excellent salary
- cost-of-living adjustments
- good chance for advancement
- many insurance benefits, including a retirement income plan

Moving Expense Allowance

Send resume to R. C. BANKS, Personnel Manager

SIKORSKY AIRCRAFT

Division of United Aircraft Corporation

Bridgeport 1, Conn.

A GOOD CONNECTION

That's what the jet pilot says when he "plugs into" the FR refueling system and that's what forward-thinking engineering personnel say when they study the opportunity for growth with Flight Refueling, a company expanding on a sound, long-range basis in the whole new field of in-flight refueling.

We have immediate openings with a future for:

DESIGNERS
CHECKERS
PROJECT ENGINEERS
TEST ENGINEERS

We need engineers with experience in design, development or testing of mechanical and electrical equipment, preferably in the aeronautical field. We also need engineers with background in aircraft fuel system component and materials development.
Your resume giving details of education, experience, and salary requirements will be held in strict confidence. Address reply to: Personnel Manager.

FLIGHT REFUELING Inc.

DANBURY, CONN.

1953

AERONAUTICAL ENGINEERING CATALOG AVAILABLE

CONTENTS:

- Complete technical data on hundreds of aircraft parts, materials, accessories and equipment.
- Over 45,000 individual listings to the manufacturers of more than 2,500 aircraft and guided missile parts.
- The names, latest addresses, and description of products of the principal manufacturers of every type of aircraft and guided missile component now being produced.

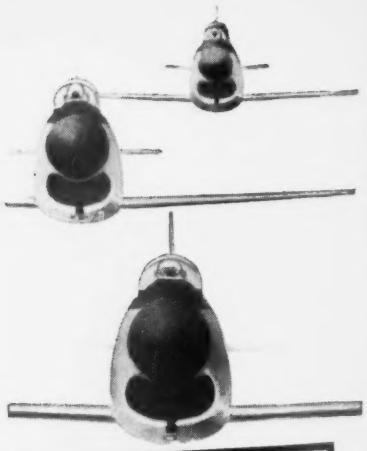
ONLY A FEW COPIES LEFT

I.A.S. MEMBERS—1 Copy: Free of Charge (Additional Copies—$7.50 per copy)

NON-MEMBERS—$7.50 per Copy

(Send Check or Money Order)

INSTITUTE OF THE AERONAUTICAL SCIENCES
2 East 64th Street New York 21, N. Y.



Engineers—

PICK A WINNER

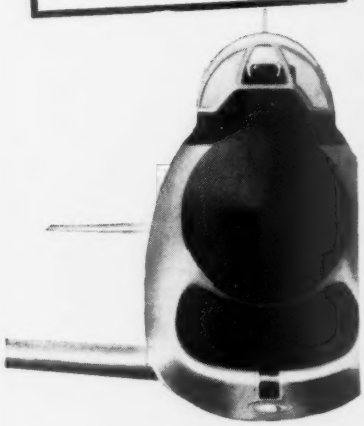
The Engineering Department which designed the **Sabre** and other headline-making military airplanes has openings for engineers—experienced in aircraft, recent engineering grads, or men from other fields with adaptable experience. Long-term military projects and twenty-five years of continuous expansion underwrite your future at North American. Current openings in:

All Design Fields

Thermodynamics | Aerodynamics
System Analysis | Structures
Servo-mechanisms | Electronics

Specialists in all major aircraft fields

Liberal travel and moving allowances



Write to

North American Aviation, Inc.

DEPT. 1, ENGINEERING PERSONNEL OFFICE
LOS ANGELES INTERNATIONAL AIRPORT
LOS ANGELES 45, CALIFORNIA
or
COLUMBUS 16, OHIO

NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD